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GRAVEL SCREENING AND WASHING PLANTS.

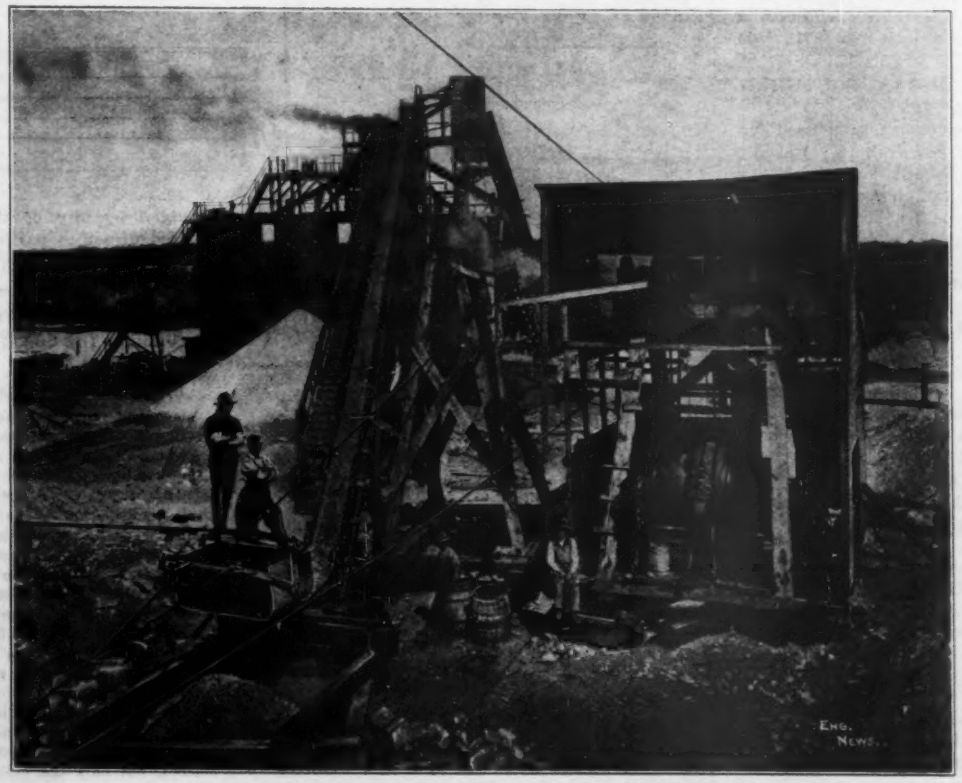
Gravel is a material which is largely used for a variety of purposes in engineering works, but bank gravel in its natural condition contains sand and pebbles (or stone) in very varying proportions, and also usually contains too large a proportion of sand, loam or clay to make it suitable for use without some treatment. With the growing use of gravel for concrete work, there is an increasing demand for screened and washed gravel, so as to ensure a clean material and a better proportioning of sizes in the aggregate than can be obtained by the use of bank gravel. The dusty and dirty character of much of the ordinary gravel used for railway ballast has also led to some use of washing and screening processes for gravel for this purpose. Sometimes this gravel is used for the entire bed of ballast, while in other cases it is used as a top dressing to keep down the dust and to maintain the track in better surface.

AMERICAN SAND & GRAVEL CO.'S PLANTS.

The American Sand & Gravel Co., of Chicago, operates twelve sand and gravel pits in different parts of Illinois and Indiana, and three of these (at Camp Lake, Carpentersville and St. Charles) are equipped with gravel washing plants. The largest of these is at St. Charles, and has a capacity of output of about 600 cu. yds. of treated gravel per 10-hour day. This company will supply an average of about 25 cars daily until December to fill its contract for 125,000 cu. yds. of gravel for the monolithic reinforced concrete warehouse of Montgomery Ward & Co., in Chicago. The use of gravel in place of stone in this building was adopted after extensive tests and investigations by the architect and engineers.

The company has at St. Charles about 40 acres of land, underlaid by a bed of gravel from 30 to 35 ft. deep, with but a thin cover of stripping. The stone is very hard. A view of the plant is shown in Fig. 1. The gravel is excavated by a scraper bucket of 33 cu. ft. capacity, handled by a cableway. The cut is made on the outgoing trip; the bucket is then raised vertically, and runs by gravity to the other end of the cableway. Here it is automatically dumped into a hopper, the top of which is closed by a screen of bars forming a mesh of about 6 × 6 ins. The few large stones retained on this are thrown out. The gravel falls through this screen upon an inclined belt conveyor, 250 ft. long. The belt is of canvas 24 ins. wide, and has given excellent service, having been in use some three years. It is painted every season, as a mechanical protection.

This conveyor delivers the material at the head of a hopper where a stream of water from a 4-in. pipe is delivered directly upon it from above. This washes it through the first preliminary screen, the sand and water passing away down a waste flume. This first screen is a conical drum, with its axis horizontal. The rejections fall through a chute to an Austin crusher, the product of which is elevated by a bucket conveyor and returned to the washing hopper. The washed gravel from the first screen is separated into four sizes by being passed down an inclined chute and in succession over four flat screens. At the Elgin plant, however, whose product is also absorbed by this company, four conical screens similar to the first are arranged in a series of steps connected by short chutes which enter the larger (open) end of the next screen below. The material passing through the mesh is thus delivered to the next screen. The material retained slides down the inclined face of the screen and falls out at the larger end, being discharged into a chute delivering it to the storage bin.



GRAVEL WASHING PLANT AT ST. CHARLES, ILL.

(At the right is the engine of the excavating cableway. The cableway bucket, on which the men are standing, delivers to the inclined belt conveyor. At the head of the latter is the washing apparatus, and the material then goes to the cylindrical bins.)

The washed and screened gravel from the several stages is delivered by chutes into four vertical cylindrical steel bins 14 ft. diameter and 40 ft. high. These stand between two railway tracks on foundations of concrete (reinforced with pieces of old steel cable and other waste metal), and have spouts for delivering the contents into cars on either track. The bins are filled with coarse stone to the level of the spouts, and each has a capacity of 110 cu. yds. above that level. The sizes as graded by the screens at this plant are 2-in., 1-in., ½-in., and ¼-in. down to sand. A few years ago all gravel rejections were put in waste piles at the pits, but owing to a growing demand, the entire product of these gravel washers is now being used. One thing in its favor is that all dust is washed out and that 75% is either granite, trap rock, quartz or other hard material, which is claimed to be preferable to pure limestone, especially when used in fireproofing for buildings.

The conveyors and crusher are operated by rope-transmission from a 100-HP. Corliss engine, while the excavator is handled by a hoisting engine mounted near the discharging end of the cableway. The entire equipment, with the exception of the crusher and the storage bins, was built and erected by the Stephens-Adamson Mfg. Co., of Aurora, Ill.

STEWART-PECK SAND CO.'S PLANT.

The Stewart-Peck Sand Co., of Kansas City, Mo., is now operating a large gravel washing plant at Horatio, Ark. The machinery was built and erected by the company. The gravel in this case contains such a considerable proportion of clay that it was practically useless for railway ballast until the washing process was used. The bed is about 20 ft. deep and is underlaid by an 8-ft. stratum of calico clay. A 2-yd. Bucyrus steam-shovel is used, and the material is loaded into 1½-yd. dump cars. A mule team hauls three of these cars to the washer plant, where the gravel is dumped into a tank or trough.

The washer, shown in Fig. 2, consists of two hexagonal troughs or "logs," 18 ins. diameter and 18 ft. long. In each of these is a shaft with flukes or blades set spirally so as not only to agitate and churn the gravel, but also to feed it forward to the delivery end of the cylinder. The two troughs are slightly inclined, the receiving end being 6 ins. lower than the delivery end. The troughs are enclosed in a tank or box, and above and between them is a 5-in. water pipe having ¾-in. holes 3 ins. apart. These streams of water are directed into the troughs, and the water passes off at the lower ends, with the clay in solution. The water is pumped through an 8-in. pipe line about a mile in length.

From the upper end of the trough the gravel falls into a chute which delivers it to an inclined bucket conveyor discharging into the elevated storage bins. The gravel is not screened, but in size it ranges from ⅛-in. to 3 ins. The loading track for railway cars passes underneath the bins. The plant is driven by a 100-HP. engine, and requires 20 men in its operation.

The plant has a capacity of 120 to 130 cu. yds. per hour. It cost about $25,000, and the company makes a profit from ballast sold at 40 cts. per cu. yd., but considers that the process could not be economically employed for an output of less than 500 to 600 yds. per day. About 400,000 cu. yds. of washed gravel have been furnished to the Kansas City Southern Ry., and some has also been used for commercial purposes. It is used by the railway for ballast and concrete, and also for covering the floors of its solid-floor trestles to protect them from fire due to cinders from the engines. The floor is made of ordinary bridge ties laid close together, with the rails spiked to them in the usual way, and is then covered with about 3 ins. of gravel. Fig. 3 shows the form of ballast cross-section employed with this washed gravel.

LAKE SHORE & MICHIGAN SOUTHERN RY. PLANTS.

Screened and washed gravel has been used for ballast for more than two years, mainly west of Toledo, and is giving excellent service. That which has been used so far, however, is only for the first 6-in. lift of the track, covering the old ballast of ordinary gravel. The track will be given another lift or raise this year with the washed gravel. This material will be given a good trial, but we are informed that broken stone will probably be adopted as the standard, at least east of Toledo. The road is now commencing the use of stone ballast at the Buffalo end of the line. The company operates two gravel plants at South Bend and Pleasant Lake, Ind. The capacity is such as to handle the entire output from a 75-ton 3½-yd. steam shovel at the pit, so as to furnish as great a quantity of screened ballast as the shovel could furnish of unscreened ballast. This eliminates the tendency to use ordinary gravel on account of insufficient supply of the better material. The capacity is about 2,000 tons per day (150 to 200 cars). The drop-bottom cars from the gravel pit are run upon a track having two hoppers, into which the material is dumped. From each hopper an inclined link-belt conveyor carries the gravel to the top of a trestle or frame about 50 ft. high and delivers it at the head of a chute 6 ft. wide and 8 ft. long. Down this it is washed by a jet of water, from an 8-in. pipe having a wide flat nozzle, so that the stream of water covers the width of the chute. A preliminary screen removes all stones over 2 ins. in size. At one of the plants this is a bar screen; at the other a revolving screen is used. The rejections from this fall through chutes to a crusher, the product from which is elevated by a bucket conveyor to the washing chute. The material passing the bar screen goes first to a ¾-in. screen, then ¼-in., and, finally, a double screen having a 3-16-in. and ⅛-in. mesh close together. These are stationary flat screens, 8 and 10 ft. wide, inclined only slightly from the vertical, and the material which passes through each rolls down an inclined platform to the next one. That held by the screen falls direct to the bin above the loading track. The sand which passes all the screens goes to a settling device, where the water is drained out, and then to a storage bin. The screens are specially made from piano wire.

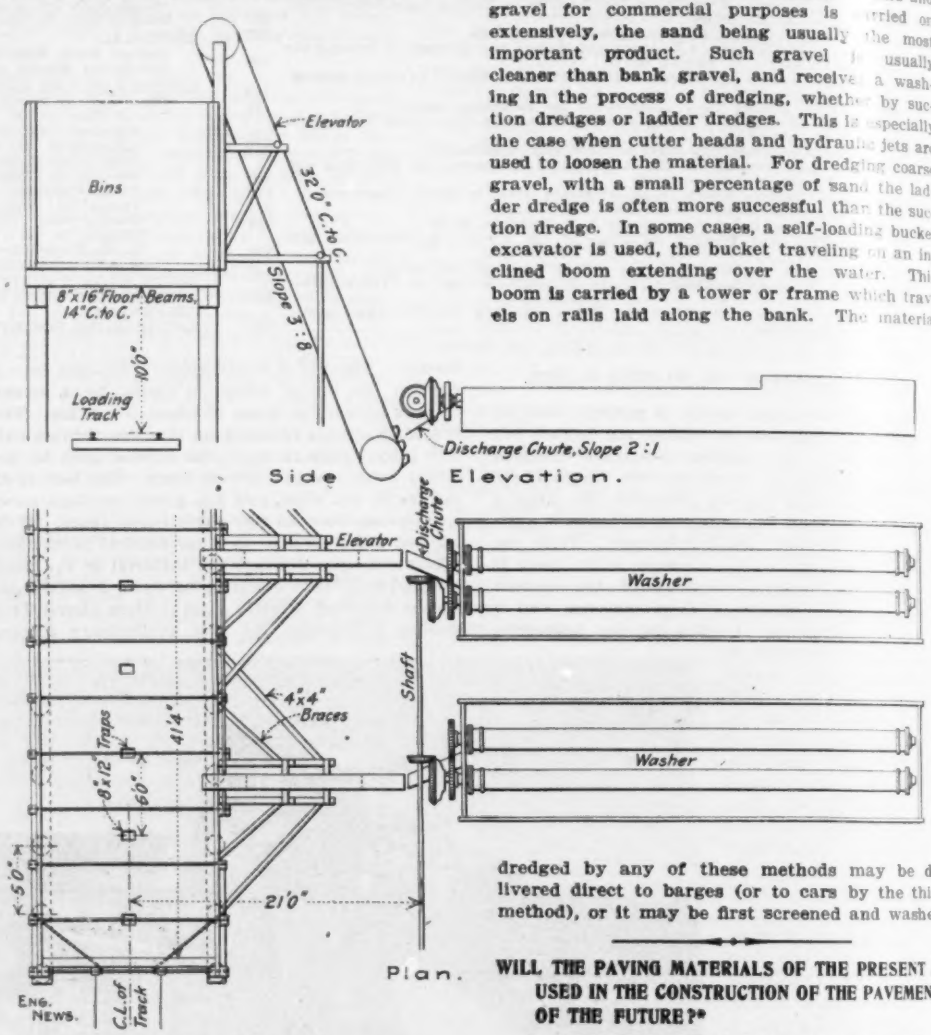


FIG. 2. GRAVEL WASHING PLANT AT HORATIO, ARK.
Stewart-Peck Sand Co., Kansas City, Mo.

The washed gravel, ready for use, costs from 23 to 30 cts. per cu. yd., while the cost of stone ballast is from 50 to 75 cts. The washed gravel represents 40 to 65% of the raw gravel, the balance being sand that passes all the screens. It has been stated that the gravel originally used for ballast contained from 50 to 70% of sand. It not only made a very dusty track, but it was difficult to maintain the track in surface, as the rain washed out the fine sand, causing continual settlement.

MISCELLANEOUS PLANTS.

The Pugh portable plant for excavating and washing gravel consists of apparatus mounted on cars and moved slowly along a track parallel with the face of the gravel pit. The excavator is a scraper-bucket handled by a long boom projecting from the side of the front car, and this delivers the gravel to the screening, crushing and washing apparatus. It has been found more satisfactory and economical, however, to have a stationary washing plant independent of the excavating machinery. This plant was at one time used to handle gravel for ballast for the Kansas City Southern Ry. and the Chicago & Alton Ry. It was described and illustrated in our issue of Feb. 18, 1904.

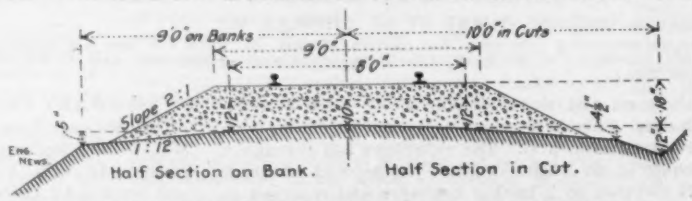


FIG. 3. CROSS-SECTION FOR BALLAST OF WASHED GRAVEL; KANSAS CITY SOUTHERN RY.

On many large rivers the dredging of sand and gravel for commercial purposes is carried on extensively, the sand being usually the most important product. Such gravel is usually cleaner than bank gravel, and receives a washing in the process of dredging, whether by suction dredges or ladder dredges. This is especially the case when cutter heads and hydraulic jets are used to loosen the material. For dredging coarse gravel, with a small percentage of sand the ladder dredge is often more successful than the suction dredge. In some cases, a self-loading bucket excavator is used, the bucket traveling on an inclined boom extending over the water. This boom is carried by a tower or frame which travels on rails laid along the bank. The material dredged by any of these methods may be delivered direct to barges (or to cars by the third method), or it may be first screened and washed.

WILL THE PAVING MATERIALS OF THE PRESENT BE USED IN THE CONSTRUCTION OF THE PAVEMENTS OF THE FUTURE?*

By GEORGE W. TILLSON,† M. Am. Soc. C. E.

When one remembers that thirty years ago there was not a mile of the standard pavements of to-day in existence in America, is it strange that the thinking engineer wonders what new developments in street pavements will take place during the next thirty years? Will the principal changes be in the materials used, in the methods of using them, or both?

The perfect pavement has never been constructed. The speaker has no hesitation in stating that municipal engineers in charge of pavements have failed to solve satisfactorily the problem presented to them. In most constructive work, any result can be obtained if sufficient funds are available. An architect can build any kind of a residence desired; a bridge engineer can erect a bridge that will satisfy perfectly the requirements of traffic, and be pleasing to the eye; but a pavement engineer cannot lay a pavement that will be entirely satisfactory; and, in this statement, durability is not considered, but only the public requirements. A pavement is laid primarily to sustain traffic, but, no matter how well it does this, it is not a complete success unless it can be cleaned easily and is neither slippery nor noisy. What pavement will satisfy the above four requirements? But, to go further. Pavements are laid for the convenience of the public, and should an engineer be fortunate enough to construct a pavement that would fill these conditions, if it were of such a character that it would wear out quickly and require constant repairs, it would be a failure. Any interruption of the traffic of a street interferes seriously with business, and often causes material financial loss; so that it can be said that the perfect pavement must not only have the properties named above, but must be so durable that its necessary repairs will not obstruct traffic seriously.

*Opening of an informal discussion on pavements at the annual convention of the American Society of Civil Engineers, July 10, 1907. Condensed from Proc. Am. Soc. C. E., Vol. XXXIII., pp. 1-5, August, 1907.

†Engineer of Highways, New York City.

The proposition then is, can the perfect pavement be constructed or approximated with the materials now prevailing, or must new materials be used? When it is known that the great improvements in pavements that have been made in the last thirty years have been mainly in the use of many new materials, the latter might be expected; but the speaker believes that the engineer himself is at fault, that he has not made the most of his opportunities, and that he has not made sufficient study of the needs and wants of each individual street. He appreciates fully, too, that, very many times, reasons other than engineering determine the character of the particular material. But he believes that too often an asphalt pavement is considered simply as an asphalt pavement, a wood pavement as only a wood pavement, without any serious consideration as to just how it should be laid to meet the requirements of any particular location. Specifications are too general. By a little study the cost of a pavement on one street may be reduced sufficiently to permit improvements to be made to a similar pavement on another and more exacting street, and the result may be two pavements which are relatively equal.

STONE BLOCKS.—It is admitted by all that the first-class stone streets of Europe are better than streets of a similar class in America. The difference is principally in the blocks themselves. They are better dressed and more uniform in size. If more attention were given to the making of the granite blocks in America, the pavements would be less noisy and much more durable; and, as the noise is one of the greatest objections to stone pavements, anything that will reduce it is an important improvement. Granite as it is used becomes smooth and consequently slippery. This can be helped by making the blocks smaller; and, if they are well dressed, they can be set closely together, and so make it practicable to fill the joints with a bituminous paving composition alone, without gravel. This would also greatly reduce the noise. If automobile trucks come into general use, as they now bid fair to, the question of noise, now so important, will gradually grow less, and a pavement of well-dressed granite blocks, from 3 to 3½ ins. thick, laid close together, with joints filled with some bituminous or similar mixture, will be very satisfactory for many streets.

BRICK.—One of the greatest objections to a good brick pavement is that it is noisy. It is often difficult, however, to tell by preliminary tests how satisfactory an unknown brick will be in a pavement, the product of different kilns often requiring different tests to enable the engineer to determine which is the best specimen. As brick is a material which is so available for many interior cities, and has given such excellent results, as far as durability is concerned, any practical change in methods which will reduce the noise will be of great benefit. As the speaker has had a limited experience with this material, he feels somewhat diffident about making suggestions, but thinks that, in addition to having the joints filled with a yielding substance, if the bricks themselves could be bedded in the same material, without too great an expense, the noise from the traffic would be materially deadened.

ASPHALT.—The construction of coal-tar pavements in Washington, some thirty or more years ago, and their development into the bituminous pavements of to-day, has made a greater change in street conditions than anything that has occurred since streets began to be improved. They filled several long-felt wants, as they were smooth, comparatively noiseless, and easily cleaned. Thousands of miles of such pavements have been laid since 1877, and their popularity is still increasing. The pavement mixture is artificial, and consequently is subject to considerable variation. There is no class of pavements that taxes the ingenuity of the expert as much as the bituminous ones. When these pavements were introduced they were constructed according to the specifications of the contractor, who guaranteed them for a term of years. This practice has been kept up, to a certain extent. Few city officials hold their positions long enough, or have sufficient facilities for studying such subjects thoroughly enough, to decide arbitrarily on asphalt specifications. The general public looks askance at specifications prepared by contractors, but what can be done? The only thing is for the official to have sufficient knowledge to determine whether the conditions are drawn in the interest of the contractor or the city. Few engineers of the country are qualified to design asphalt pavements for different conditions. That is one reason why such pavements have so often failed. They were not properly designed for their work. The one great defect has been in the foundation, but the wearing surface is of great importance. An asphalt pavement is like a carpet laid upon a floor. Both the carpet and the floor must be good, or the result is bad; a failure in either causes a failure in both.

The three forms of bituminous pavements now in use are sheet asphalt, asphalt block, and the bitulithic. Sheet asphalt pavements made the reputation of such pavements. The main objections to them are that they are slippery, and will not stand heavy traffic. Both these objections can be helped, if not overcome, by proper design. Clifford Richardson, Assoc. Am. Soc. C. E., in a paper recently read before the Society of Chemical Industry, advocated a pavement made up of a 6-in. concrete base upon which was to be laid 2 ins. of a solid binder, covered with a 1½-in. wearing surface, this to take the place of the 1 in. of loose binder and 2 ins. of wearing surface now in use. The speaker firmly believes that such a pavement would prove a success on many streets where the traffic now seems to be too heavy for asphalt. A proper selection of the materials for the wearing surface will undoubtedly reduce greatly the excessive slipperiness, although a hard, smooth surface must be slippery to a certain extent unless kept perfectly clean.

The asphalt block pavement is designed for steep grades. The aggregate of which the blocks are formed is coarser than in sheet asphalt, and this, together with the joints formed by the blocks, gives horses a better foothold. Good blocks will make a good pavement, and elaborate experiments are now being made in order to determine a proper test for, and a proper method of testing, these blocks, so that their value can be determined before they are used.

BITULITHIC.—The bitulithic pavement is expected to be smooth and not slippery. Its inventor started out to improve macadam, but finished by producing a new pavement. It has been used extensively and satisfactorily during the past five years, but the speaker's personal experience with it has been so slight that he will not attempt to discuss it.

WOOD BLOCKS.—The modern wood pavement, when dry and first laid, is practically ideal. It is smooth, noiseless, and is easily cleaned. It is slippery, however, in moist or frosty weather. That is its greatest fault. If this objection can be overcome, it is bound to have a great future, especially if its preservative treatment is sure. It is expensive, however, and, as all lumber is increasing in value from year to year, it would seem to be difficult to reduce or maintain its cost as at present. This may possibly be done by obtaining different varieties of wood for use. It must be understood, however, that there is no material used in the constructive arts the value of which is so difficult to determine in advance as wood, and great care must be exercised in deciding to use a new variety. The kind which has been generally used is long-leaf, yellow pine, but this, while good, is expensive and is becoming more so from year to year. This wood comes from one section of the country, so that transportation expenses are high. The problem, then, is to discover, if possible, different kinds of wood, in different sections of the country, which can be used to advantage.

In summing up, then, the speaker would say that, in his judgment, the improvements in street pavements in the future are to be brought about by a different use of materials now in vogue, rather than by the adoption of entirely new materials. That, by studying the needs of the different streets to be paved, by using present materials intelligently, both as to manner and combination, the municipal engineer can bring about results which, if not entirely satisfactory, will be a vast improvement over present practice.

A REPLACEMENT OF ALL CEMENT-LINED PIPES by cast-iron at Salem, Mass., is recommended in a report on the water supply and fire protection of Salem, just issued by the Committee on Fire Prevention of the National Board of Fire Underwriters (135 William St., New York). Of 55 miles of mains in service, 22.4 miles is of cement-lined pipe which has been in use over 30 years. The report states that "leaks and breaks in this pipe have been very frequent."

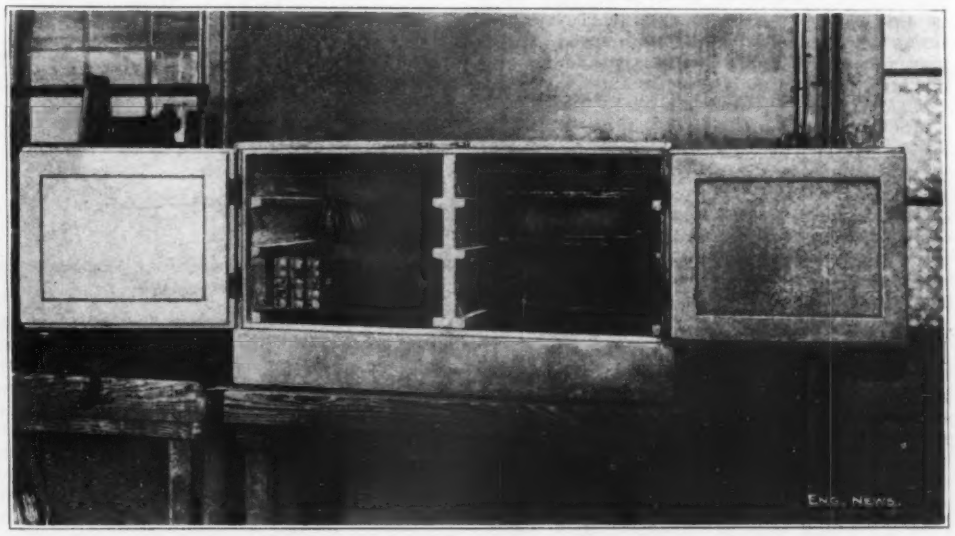
A REINFORCED-CONCRETE MOIST CLOSET FOR THE CEMENT TESTING LABORATORY.*

By ERNEST B. McCREADY.†

The moist closet herein described is fully equal to the slate or soapstone closet usually found in cement testing laboratories, and may be made in any laboratory with a minimum of cost. It was made of "waste cement" left from testing—all brands mixed—and several samples of natural sand from the same source.

The mortar was mixed 1 to 2 and wet enough to be readily filled into and tamped down in a ⅝-in. space. The walls are 1¼ ins. thick, except the center panels of the doors, which are only ½-in. thick. The walls are reinforced with ½-in. mesh galvanized wire netting. The necessary forms can readily be made by any carpenter and consist of an outside form or box without top or bottom and two inside forms or cores which are simply boxes with tops but no bottoms. As the closet is cast face or front down, the top of the forms means the back of the closet. When the forms are in position, there must be 1¼-in. clearance all around each core—top, bottom and sides.

The doors are cast first by filling in a frame of the proper dimensions, laid on a pane of glass or other flat surface, which has been oiled. The hinges are placed by marks on the frame and secured thereto by small brads before the mortar is filled in. The same form answers for the two doors by simply reversing the position of the hinges. (If made like those illustrated, the hinges must be "right" and "left.".)



MOIST CLOSET FOR CEMENT TESTING LABORATORY MADE FROM REJECTED SAMPLE CEMENT AND SAND.

When hard enough to stand handling, the two doors are placed, in their proper relation, face down, on a flat surface and the outer box-form placed around them. The edges of the doors are covered with several thicknesses of oiled paper and the cement mortar filled in around them level with the doors, making the layer of mortar just 1¼ ins. thick. The inside forms are immediately placed in position, open end down and are supported by the doors which are sufficiently hard. If correctly made, they will reach to within 1¼ ins. of the top of the outer form and there will be an open space of 1¼ ins. all around each core. The mortar is then filled in around and over these cores and smoothed off even with the top edge of the outer form; this top layer forming the back of the closet.

Of course, the placing of the reinforcement adds slightly to the detail of these operations. The doors and the back are filled in two layers with the wire placed between. The wire for the sides—in one piece—is placed in position and kept in the middle by strips of half inch board which are moved along or taken out as the mortar is filled in.

The doors may be panelled and their weight reduced by placing in the frame, before and after filling, a piece of plate glass, slate or even wood of the desired shape and thickness. These are removed after the mortar has hardened.

The forms must be thoroughly shellaced and oiled before use. The cores must be put together with screws, entirely from the inside and exposed ends and edges slightly beveled so that they may be removed after the cement has set.

The shelf cleats are provided for by longitudinal strips on the ends of the core boxes, in width equal to the

*Part of paper read at annual meeting of the American Society for Testing Materials at Atlantic City, June 21, 1907.

†General Manager, Lehigh Valley Testing Laboratory, Allentown, Pa.

distance desired between the cleats. The space between, when filled with mortar, makes the cleat.

The appearance of the closet may be enhanced by thoroughly moistening the green surfaces after the removal of the forms and sifting some neat cement lightly and evenly over the whole from a 50 or 80 mesh sieve.

This closet has been in use a little over a year and has given great satisfaction. It is water-tight and requires no felt lining to maintain a uniform degree of humidity, since the cement walls themselves take up and distribute moisture. By actual repeated tests, we have found the percentage of saturation on the top shelf to be as high and often a little higher—owing, perhaps, to a slight difference in temperature—than at the surface of the water.

RIVER FLUSHING PLANTS AT MILWAUKEE, WIS.

The city of Milwaukee is intersected by three rivers, all converging to one outlet into the lake, as shown on the sketch map, Fig. 1. The Menomonee River runs east to the lake and has several artificial branches or canals in the manufacturing and packing-house districts. The Milwaukee River runs south and the Kinnickinnic River runs north and northeast. The natural flow of all these streams is very sluggish, and in fact the current is frequently reversed by high winds on the lake. As there is a large discharge of sewage and industrial wastes into these streams they became exceedingly foul. Means for improving these unsanitary conditions have now been applied to all three streams. In the case of the Menomonee River and canals, all of the sewers emptying into them have been intercepted by connections to a low-level intercepting sewer which also takes water from the heads of the several canals, but this is not adequate for present conditions, as noted below. Both the other rivers are now purified by an artificial flow caused by pumping clear water from the lake into them above the points where fouling occurs.

MENOMONEE VALLEY.

A system of low-level intercepting sewers for this district was adopted in 1880. In 1882, Mr. Geo. H. Benzenberg, M. Am. Soc. C. E., then city engineer, changed the plans of some of these so that they would be below the levels of the canals, the upper ends of which were then provided with connections to the interceptors. There are two siphons, one crossing the North Menomonee Canal and the other crossing the Milwaukee River; the latter leads to the pumping station on the strip of land between that river and the lake. The pump is a horizontal tandem compound engine connected to the vertical shaft of a 12-ft. pump disk or wheel. The speed is 65 to 70 r. p. m., and the capacity 70,000,000 gals. per 24 hrs. with 10-ft. lift. The sewage is drawn up from the suction well and discharged over the rim of the pump into a 6-ft. outlet conduit leading to the lake. This plant was started in 1885, and has been in continuous service with the exception of a few weeks each year for inspection and repair.

A tunnel and pumping plant for flushing the Menomonee River, on the same general plan as that now in use for both the Milwaukee River and the Kinnickinnic River, has recently been suggested. A serious difficulty, however, is that while the two latter streams approach the lake diagonally and are reached by tunnels of comparatively short length, the Menomonee River is practically at right angles to the shore line, so that a very long tunnel would be required. The present flushing tunnels are about ½ mile and 1¾ miles long (as noted below), while a tunnel to a point above the sources of pollution of the Menomonee River would be about five miles in length. The much greater cost involved in this case will prevent any such improvement being carried into effect for some years at least.

MILWAUKEE RIVER FLUSHING PLANT.

In a paper on the sewerage system of Milwaukee, presented by Mr. Benzenberg at the Engineering Congress held at the Chicago Exhibition of 1893, it was stated that in 1887 the Milwaukee River was perhaps as black, foul and offensive as any stream in the country, from 10,000,000 to 13,000,000 gals. of sewage and factory liquids being discharged into it daily. Mr. Benzenberg proposed to construct a flushing tunnel from the lake, and to pump into the river (just below the dam) a volume of water sufficient to replace the volume of water in the river every 24 hours. In spite of very strong opposition, the project was authorized, and the contract was let in December, 1887. Pumping was started on Sept. 14, 1888. The possibility of purifying the river in this way had been doubted, but its efficiency was proved in less than 24 hours by the color and transparency of the water, and within a week there was practically no difference between the water in the lake and that in the river. In fact, in a very short time fish were living in the stream. The tunnel is 2,500 ft. long, 12 ft. inside diameter, and has a shut-off gate at each end. The pumping plant was of a novel character, designed by Mr. Edwin Reynolds, M. Am. Soc. M. E., and built by the E. P. Allis Co. The pump consisted of a propeller wheel 14 ft. in diameter, with a pitch of 8 ft., placed across the tunnel at its intake end, and driven at 60 r. p. m. by a vertical steeple compound engine with cylinders 19 × 48 ins. and 38 × 48 ins. This forces into the

Fig. 1. Map Showing Location of Flushing Plants at Milwaukee, Wis.

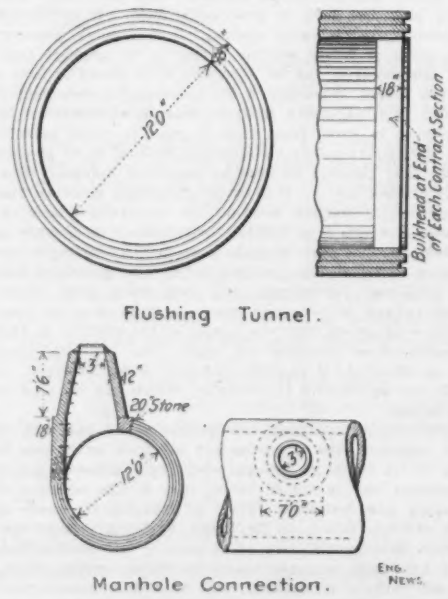


Fig. 2 Kinnickinnic River Flushing Tunnel.

tunnel and river 46,080,000 cu. ft. (345,600,000 gals.) per 24 hrs., with a head of 3 ft. against the wheel. The duty test in 1888 developed 75,944,037 ft.-lbs. In the year 1889 the average duty (including coal for the heating and electric lighting of the pumping station) was 68,844,912 ft.-lbs. per 100 lbs. of coal.

KINNICKINNIC RIVER FLUSHING PLANT.

The condition of the Kinnickinnic River was very much the same as that of the Milwaukee River, and as the pollution became more and more offensive it was decided to purify it in the same way as that which had been employed with such signal success for the latter. Work was commenced in 1899, but the flushing system was not completed and ready for service until June, 1907. The tunnel is about 7,364 ft. in length, and extends from an intake basin on the lake shore at the end of Russell Ave. to a pumping station and outlet at the Kinnickinnic River near the Chicago Road bridge, as shown in Fig. 1. This outlet is about 2.33 miles above the mouth of the river, the channel of which averages 20 ft. in depth and 200 ft. in width, with a cross-sectional area of 4,000 ft. While the water in the river has been practically stagnant, the flushing plant will create a current of about 9 ft. per min., with a discharge of about 324,000,000 gals. per 24 hrs., or a sufficient volume to change the whole body of water in that time.

TUNNEL.—The tunnel, Fig. 2, is 12 ft. in diameter, and has a fall of 4 ft. in its length. There are two single curves and two sets of reverse curves, all but one of these being of 150 ft. radius. The depth of material over the roof is from 12 to 70 ft., and the entire work was driven by tunneling, with the exception of 433 ft. of open cut work in crossing the old channel of Deer Creek. The material excavated was principally clay, but the Deer Creek channel was of marl, and a small pocket of quicksand was encountered. The specifications provided that no extra pay would be allowed to the contractor on account of any material except solid rock; for this $6 per cu. yd. would be paid, no allowance being made for excavation more than 6 ins. beyond the line of the outer ring of masonry. The excavation was required to be made to fit the outside diameter of the brick lining, all hollow spaces to be filled solid and compact with clean sand, brick masonry, or concrete (as required) without extra cost. It was also provided that where the nature of the ground should require the work to be reinforced, additional rings of brickwork or a ring of concrete should be used. For this the specifications provided a price of $20 per 1,000 bricks or $7 per cu. yd. of masonry, including work and excavation. An extra ring of brick was used only in passing through the Deer Creek channel and the pocket of quicksand.

The work was done in four sections. The west (or lower) end of each section was closed by an 18-in. brick bulkhead; this was removed by the contractor for the next section below, who was required to provide for the water in the upper section and to make the proper toothing connection of the brickwork.

The specifications called for the tunnel lining to be of best-quality, hard-burned, clear-ringing, well-made Milwaukee sewer brick, free from lime. The bricks were required to be clean and thoroughly wet before laying, and those with the smoothest surfaces were selected for the inside face of the tunnel. The shell or lining consists of four rings of brick, all bricks laid as stretchers, with toothing joints; interior joints not to exceed ¼-in.; and collar joints to be not less than ⅝-in. The bricks are laid in mortar of 1 part American hydraulic cement and 2 parts of sand. The full mortar joints under bottom, sides and ends were required to be formed by one operation for each brick, and not made by working the mortar in after the brick was laid. The outside of the arch was plastered with mortar and the work was required to be watertight. Provision for the natural settlement of the masonry was made by allowing 3 ins. above the regular height in making the centers of the arch.

There were eight working shafts, which were required to be not less than 10 ft. square. Three of these were utilized for permanent manhole shafts, the others being filled with earth. The manhole shafts, Fig. 2, are built over half the width of the tunnel. They are 6 ft. inside diameter, with brick lining.

INTAKE.—The intake basin, Fig. 3, is 375 ft. long and 60 ft. wide, and is formed by building two piers in the lake, extending in a northeast direction from the shore. At the shore end is an 85-ft. chamber with sides converging to the tunnel portal. Across this chamber is an iron screen. The piers have double rows of piles with inside sheathing of Wakefield sheet piling, and a filling of quarry stone.

The end chamber or screen chamber is 60 ft. long, 47 ft. 6 ins. wide at the outer end and 12 ft. at the inner end. The chamber has a floor of 2-in. dressed and matched pine flooring spiked to transverse stringers bedded in the sand. The sides are sheathed with 2-in. flooring nailed to each pile. The back wall is also built up with timbers and sheathing. The screen has its foot at the front row and its head at the top of the second row of piles across the chamber; 8-in. I-beams form the guides for the screens.

From the shut-off gate to the end of the screen chamber is a connecting chamber 12 ft. long, of reinforced concrete, 12 ft. square at the outer end and 12 ft. diameter at the inner (or gate) end.

OUTLET.—At the lower end of the tunnel, the diameter increases to 12 ft. 6 ins. at a gate chamber, beyond which is the pump-wheel chamber. Beyond this is a 55° curve of 18-ft. radius, ending in the discharge or outlet conduit, which also has a third gate chamber. The wheel chamber can thus be shut off entirely for inspection or repair of the machinery. The arrangement is shown in Fig. 4. The discharge conduit is of brick, 155 ft. long, with a diameter of 12 ft. 6 ins. to 18 ft., the latter being formed in a concrete retaining wall (as shown). One of the gates is shown in Fig. 5. The engine is placed in a pit beyond the line of the tunnel, with a steel interior shell. The bottom is formed by the engine foundation, which is a concrete mass 25 ft. diameter and 9 ft. thick. The wheel chamber has 27-in. brick walls, and a 24-in. arch roof of 7 ft. 9 ins. radius. The bottom is a concrete block 13 x 20 ft., 3 ft. 10½ ins. thick.

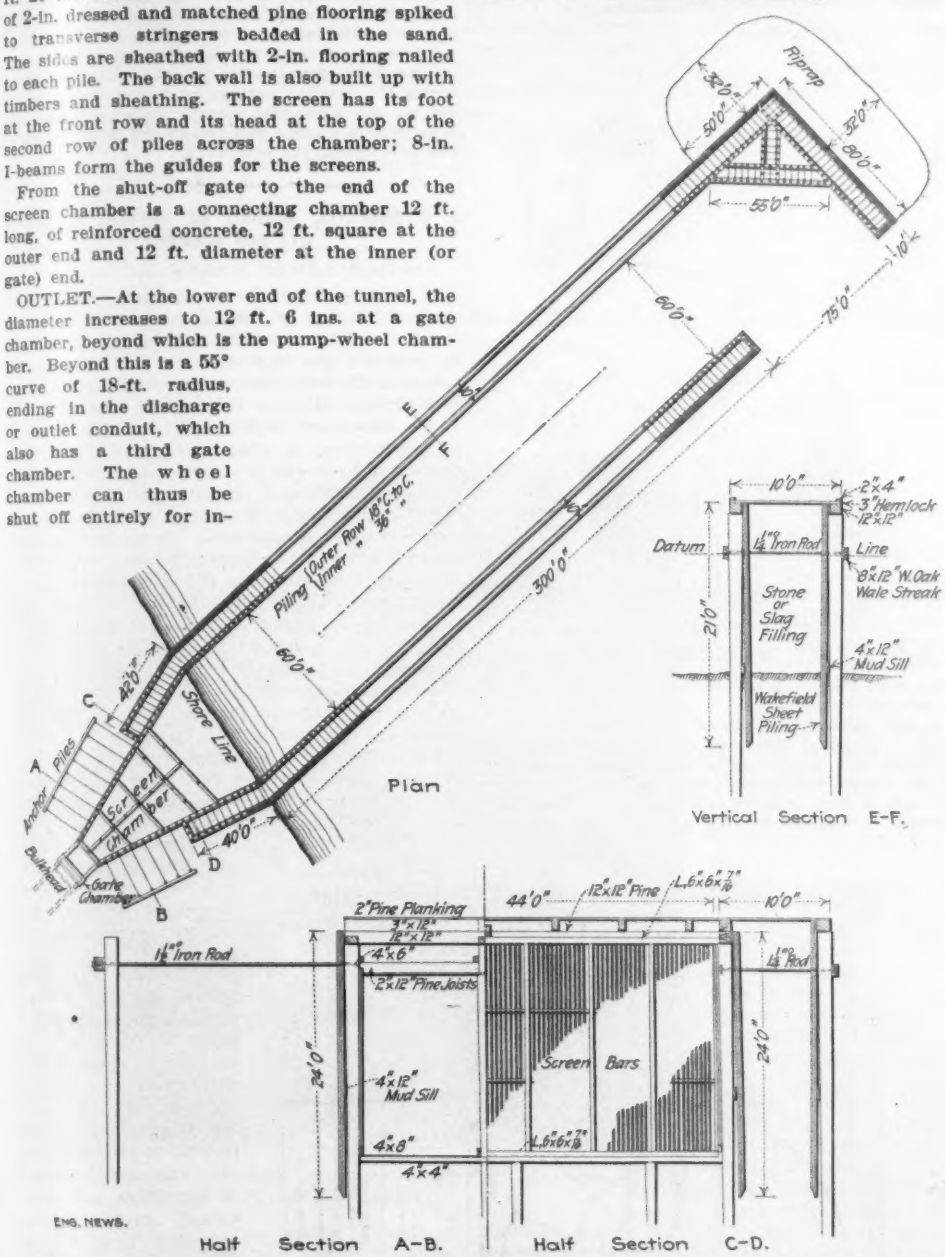


FIG. 3. INTAKE BASIN AND SCREEN CHAMBER OF KINNICKINNIC RIVER FLUSHING TUNNEL; MILWAUKEE, WIS.

PUMPING PLANT.—The pumping plant is in general similar to that of the Milwaukee River plant, already mentioned. The plant, however, is located at the discharge end, while that for the Milwaukee River is at the intake end of the tunnel. The gravity tunnel ends at the wheel chamber, across which is placed a six-bladed screw propeller wheel, 12 ft. 6 ins. diameter. This is shown in Fig. 6. The shaft of the wheel extends through a stuffing box in the curved wall of the discharge conduit and is coupled to the shaft of a vertical tandem compound engine in the engine pit above mentioned. This engine has a guaranteed duty of 95,000,000 ft.-lbs. per 1,000 lbs. of water evaporated, the steam pressure at the throttle being 140 lbs. This plant has a capacity of forcing 30,000 cu. ft. of water per minute into the Kinnickinnic River.

ENGINEERS AND CONTRACTORS.—This flushing system was designed under the direction of Mr. Geo. H. Benzenberg, M. Am. Soc. C. E., who was at that time city engineer and president of the board of public works. The details of construction and the execution of the greater part of the work were under the direction of Mr. Charles J. Poetsch, M. Am. Soc. C. E., who succeeded Mr. Benzenberg. We are indebted to Mr. Poetsch and to Mr. B. W. Perrigo, Assistant City Engineer, for plans and other information. The contractors for the tunnel sections Nos. 1 to 4 respectively, were as follows; 1, James Markey; 2, Meehan & Courtney; 3, R. Forrestal; 4, R. J. Hickey. The last-named also built the intake, while Wm. T. Duke had the contract for the outlet. The shut-off gate at the inlet end was built by the Wm. Bailey & Sons Co. The pumping machinery and the gates at the lower end were built by the Allis-Chalmers Co.

The plant was opened on July 16, 1907, in the presence of the city officials and a number of visitors, the engine being started by the mayor, Mr. Becker.

THE DETECTION OF POLLUTION IN UNDERGROUND WATERS, AND METHODS OF TRACING THE SOURCE THEREOF.*

By JOHN C. THRESH,† M. D., D.SC.

Outbreaks of typhoid fever which have been attributed to polluted waters have practically all been cases in which matter of excremental origin gained direct access to the source of supply or to the water on its way to the consumer. The author is anxiously looking out for the records of any outbreak in which the contaminating matter had to percolate through several feet of compact soil before it reached the incriminated water, but as yet has been unable to find any such record. There are many reports on single cases, or limited numbers of cases, attributed to the use of shallow well water. But in nearly every instance it is stated that sewage could practically run directly into the well; and in the cases where there is no record of the condition of the well or of its immediate surroundings, such defects may have existed and failed to be recorded. In very many of these small outbreaks, however, the proof that the disease was due to polluted water is of a most unconvincing character.

The author has had a great deal of experience in connection with outbreaks of typhoid fever, and has made an especial study of the sporadic cases which occur from time to time in nearly all districts; but has never investigated a single case in which the well water was seriously liable to the suspicion of being the cause, where the well was so placed or constructed that sewage had not more or less direct access. He is driven to the conclusion that water in slowly percolating through a few feet of compact soil cannot carry with it the microbe causing typhoid fever. Where water takes days to traverse the subsoil before reaching the well or spring, the typhoid bacillus is either filtered out or loses its life. Both filtration and time are undoubtedly important factors in water purification by the action of the soil. The more readily and directly the polluting matter can reach the water, and the greater the danger, the longer the period which elapses between the polluting matter being deposited on or in the soil and reaching the subsoil water, and the more compact the pervious soil, the smaller the danger. Hence it follows that anything in solution may traverse the subsoil and reach the water therein without being able to carry with it the living bacillus of typhoid fever.

Water derived from a compact subsoil can therefore be readily rendered perfectly safe by the proper construction of the collecting well and by adequate protection of a limited area around the source. Where the subsoil is fissured, as occurs in very many formations, unless the fissures are filled with deposits from a more superficial stratum, the risk of pollution of a dangerous character is much more serious. Even if the well is of great depth, or is far from any possible source of pollution, it must be remembered that, if polluting matter gets into an open fissure leading to the well, serious results may follow, even if the contaminating material has to travel a long distance before it reaches the well. Here, time may be a factor. The typhoid and cholera bacilli can only live for a limited time in water; and if these bacilli gain access to the water in these fissures, yet do not reach the well until after a lapse of several days, it is very probable that they will have died before entering the well, and will therefore be no longer a source of danger. Unfortunately, however, circumstances may arise greatly accelerating the rate of flow in the fissures—such as increased pumping, heavy rainfalls, or both—and although under normal conditions the well may be a safe source of supply, under the exceptional conditions it may be a dangerous source.

The fact of underground water becoming polluted is too often only discovered by a sudden outburst of typhoid fever. Such would propably never be the case were the water submitted to periodical examination. This examination should not be limited to a mere chemical analysis, as from our point of view a bacteriological examination is the more important. If examinations are made systematically, the normal condition of the water is soon ascertained; and should at any time an abnormal condition be found, its cause can be sought for, and, when detected, it may admit of a remedy.

Before making experiments with chemicals, a careful survey of the whole position must be made. The geology of the district must be studied, the depth and section of the well and the length and direction of any adits must be known, and the records of the systematic analyses

*Abstract of a paper read before the British Association of Water-Works Engineers, at Windsor, England, June, 1907.

†Medical Officer of Health to the Essex County Council.

must be considered and compared with the rainfall and with the height of the water in the nearest ponds or streams. Some information must be sought with reference to the direction of flow of the subterranean water, and as to the cone of depression caused by pumping. The position of the outcrop of the water-bearing stratum that the salt must be put directly into the subsoil water or fissure, as if spread on fertile ground a portion of it might be nitrified by the nitrifying organisms of the soil. Probably, however, in any case the amount nitrified would only be an infinitesimal portion of the salt employed. On the whole, it may be regarded as

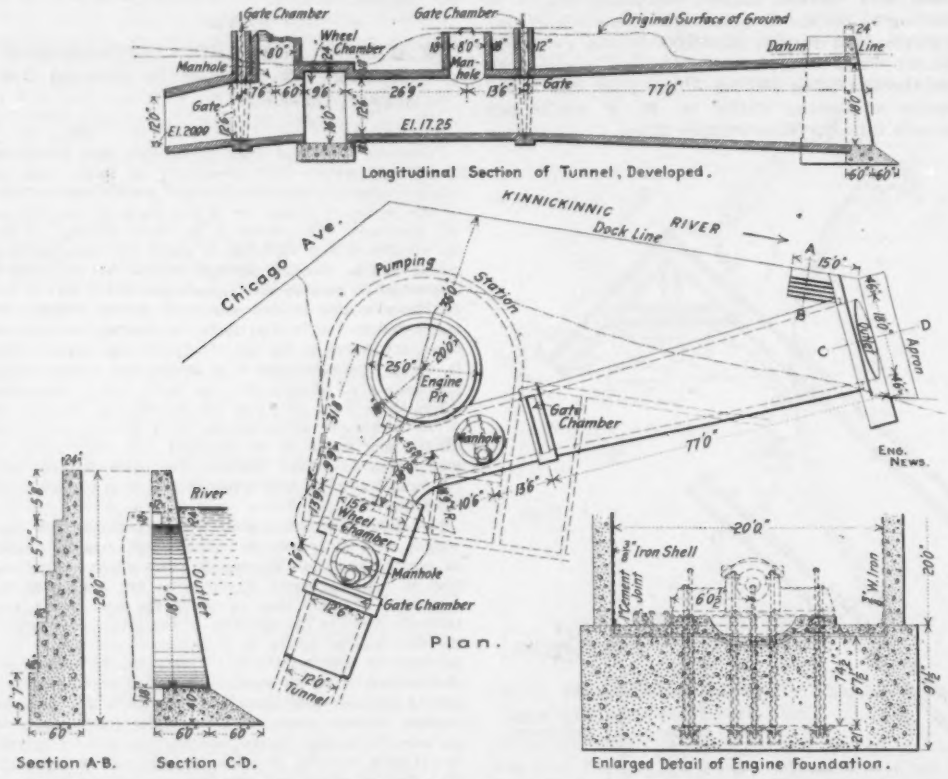


FIG. 4. ARRANGEMENT OF PUMPING PLANT AND OUTLET OF FLUSHING TUNNEL.

may also require to be known, so that it may be examined, if not too far away to be a possible source of danger. If evidence can be obtained of the presence of fissures, and of their extent and direction, it may prove of the utmost value in the investigation. All the possible sources of pollution must then be sought out and considered in connection with the knowledge so ascertained. This will enable the investigator to determine which is most likely to be the cause of the trouble, and therefore the one which should first receive attention. If such experiments as will be described shortly fail to show any connection between this possible source of pollution and the spring or well, attention must be directed to the next most probable source, and so on, until something definite has been determined.

To ascertain whether a given source of pollution can affect a given well, it is usual to introduce some chemical at the point of suspicion, and then to examine the water at frequent intervals to ascertain whether the chemical selected can be detected in it. For this purpose, common salt (sodium chloride), a lithium salt, or a dye named fluorescein have been employed; and recently the author has used ammonium salts, since, in certain cases, it possesses advantages over the others. Sodium chloride is used chiefly because it is very cheap, easily obtainable, quite innocuous, and easily detected and estimated in the water. As all waters contain chlorides, the normal chloride must be first ascertained, then any subsequent increase during the experiment may be attributed to the salt used. Slight variations are often observed in water from the same well. Consequently enough salt must be added to produce a more marked effect than any recorded in the normal water. The quantity must be at least equal to 1 grain of salt per [Imp.] gallon (= 0.6 gr. Cl.). Should it prove necessary to add this amount to a large quantity of water, the weight of salt used must be considerable, and a substitute for salt would be used.

A salt of lithium has frequently been used, but owing to its cost and the difficulties of detecting it in water it is now rarely employed.

The author has recently used ammonium chloride (sal ammoniac) in several investigations, with marked success. It is very cheap, free from color, perfectly harmless, and the ammonia, even in great dilution, admits of easy detection and estimation. When 7 lbs. costing about 3s. 6d. [85 cts.] is dissolved in 1,000,000 [Imp.] gallons of water, the ammonia can readily be detected. The amount of ammonia present in all good subsoil waters is too trifling to interfere. But certain very deep wells yield waters and many polluted waters contain very varying quantities of ammonia; hence in some of these cases the use of an ammonia salt might not lead to definite conclusions. It must also be remembered much more convenient for use than either common salt or salts of lithium.

Another substance, of an entirely different character, which is of special importance in such investigations as the above, is a coloring matter called fluorescein. Many of the aniline dyes possess enormous colorific power; but most of them, when in very dilute solution, are decolorized by filtration through soil, and others are too expensive or are objectionable in other respects. Fluorescein appears to be unaffected by passage through chalk, sand, surface, soil, &c., and when dissolved in water by aid of an equal weight of caustic soda, it can be easily detected by its fluorescence when the dilution is 1 in 100,000,000. Under very favorable conditions, 1 in 200,000,000 may be detected. In other words, 1 lb. of fluorescein will distinctly color 10,000,000 gals. of water. As the demand for this substance has increased, the price has gone down, until it can now be purchased at 7s. 6d. [$1.82] per lb., in quantities of 10 lbs. and upwards. The relative cost of these various substances used in sufficient quantity to affect 1,000,000 gals. of water would be: Fluorescein, 9d.; common salt, 2s.; ammonium chloride, 3s. 6d.; and lithium sulphate, 40s. [or as 9 to 24, 42 and 480]. Flourescein is therefore much the cheapest; it is the easiest to apply, and far the easiest to detect. There is only one possible objection to it, and that is that, if used incautiously, it may so color the whole of a water supply as to cause alarm on the part of the consumers. For this reason it is in most cases preferable to use salt or ammonium chloride in the first instance; and if, when used in moderate quantities, these give no definite results, to employ fluorescein. This dye has been largely used for tinting underground streams to trace their course, and to a certain extent for determining the direction and rate of flow of subsoil water, and one case is recorded where it unexpectedly made its appearance in a public water supply and caused considerable astonishment and some alarm.

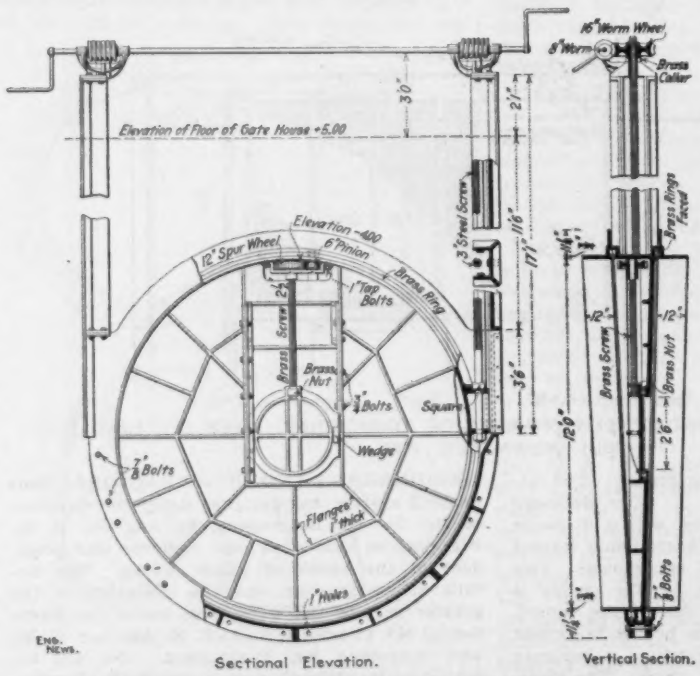


FIG. 5. 12-FT. SHUT-OFF GATE IN FLUSHING TUNNEL.

A COMMERCIAL METHOD OF TESTING PRODUCER GAS FOR SULPHUR.

By RANDOLPH BOLLING,* M. Am. Chem. Soc.

In making tests on gas producers the total sulphur content of the gases should not be omitted in the chemical examination. Sulphur in producer gas can exist in several different chemical combinations with carbon, but mainly as hydrogen sulphide and carbon disulphide. It is not necessary to determine the precise state of combination, as sulphur combined either with carbon or hydrogen is equally bad. If the total sulphur present in a certain volume of gas at a certain temperature is determined this will give sufficient data in comparing the behavior of different coals. Methods like Bunte's,† in which the gases are led into a 100 c. c. burette and a standard solution of iodine allowed to enter until no longer decolorized (the reaction being, $H_2S + I_2 = S + 2HI$), would, of course, be useful when working on illuminating gas which has been more or less purified. However, producer gas is an unpurified article at most open hearth steel plants and contains sulphur in other than simple combinations, like hydrogen sulphide, and the method would therefore fail to detect all of it. Another very excellent method which will give accurate results on any sulphur combinations is the Drehschmidt‡ process. This is based on the principle of a Bunsen burner so arranged that all of the sulphur compounds are burnt to sulphur dioxide and sulphuric acid, in passing through the intensely hot flame of the burner. It appears to be used quite extensively in illuminating gas work, but it has the disadvantage of employing quite an elaborate and expensive collection of apparatus, gas meter, special purified air supply and base for the lamp, a water, aspirator for suction and a train of absorption bottles containing a 5% solution of potassium carbonate with a little bromine. It requires very careful regulation of the air supply to keep the flame at the proper height and is likely to go out in the middle of a run. It is not a very portable arrangement and requires piping the gas to it from the producers. The method that the writer devised and is using

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†Bunte Journal für Gasbeleuchtung; 1888, vol. 31, page 808.

‡Chemekerzeitung, 1887; vol. II., page 1382.

in the laboratory of the Nova Scotia Steel & Coal Co. overcomes the trouble with the Bunte process and avoids employing the complicated appliances used to work the Drehschmidt method.

THE BOLLING METHOD.—Apparatus required: One five liter aspirator bottle, one centigrade thermometer, a barometer, two gas washing bottles of Allihn's form. The bottles should have a capacity of about 500 c. c. and should contain about 200 c. c. of bromine water and 25 c. c. of hydrochloric acid saturated with bromine. The absorbing bottles are connected by rubber tubing with each other and with the upper opening of the aspirator bottle, which, of course, is completely filled with water. The lower outlet carries a rubber stopper with a short piece of glass tubing capped by a terminal of rubber tubing carrying a pinch cock.

The apparatus is now taken to the gas producers and connected to the gas main by means of a short length of pipe packed with loose asbestos fiber. The pinch cock is opened and the gas slowly aspirated through the bromine in the absorbing bottles. When the aspirator bottle is empty, five liters of the producer gas have passed through the washing bottles. The temperature of the gas passing through the absorbing solution is noted by means of a thermometer passing through the stopper of one of them. The apparatus is then taken back to the laboratory and the bottles are disconnected and their contents transferred to a 750 c. c. beaker, carefully washing out all of the bromine water with distilled water. Now add two grams of sodium carbonate to the solution and heat to boiling temperature, on the hot plate or other safe device. After the solution begins to boil add 20 c. c. of strong hydrochloric acid and continue boiling until the bromine is boiled off. The sulphur may now be precipitated by 20 c. c. of a hot ten per cent. solution of barium chloride in water. The solution should be boiled vigorously for at least 30 min. to insure the barium sulphate coming down in a form to facilitate easy filtration. A Gooch crucible is now fitted with an asbestos felt, ignited and weighed and the barium sulphate filtered through this, heated to a dull red over a Bunsen burner, cooled and weighed.

The sulphur found is calculated for 100 cubic meters of gas at 10° C. and 760 mm. pressure. If 5.0 liters have been used for the determination, and if t denotes the temperature of the gas, f the tension of aqueous vapor at this temperature, B the barometric pressure and p the weight of the barium sulphate, then the amount of sulphur S in 100 cubic meters of the gas is:

$$S = 200.0\, p.\, 0\,13748 \times \frac{750.8}{283} \times \frac{273 + t}{B - f}$$

$$= p\ 729.47 \times \frac{273 + t}{B - f}$$

Tables for the tension of aqueous vapor can be found in most handbooks on chemical physics.

With a battery of 16 producers, charged with Sydney coal having a proximate chemical analysis as shown in the accompanying table, the sulphur calculated for 100 cubic meters at 10° C. and 760 mm. pressure, and determined at short intervals during regular work was as follows:

Test No.	Grams of Sulphur.
1	0.075
2	0.0763
3	0.0788
5	0.0761
6	0.0767
7	0.0765
8	0.0762
9	0.0764
10	0.0760

PROXIMATE CHEMICAL ANALYSIS OF SYDNEY, N. S., COAL.

Dried at 100° C.	
Moisture	3.42%
Volatile and combustible matter	35.10%
Fixed carbon	60.10%
Ash	4.80%
Total sulphur	1.94%

The advantage of the gravimetric end of the method is apparent, especially when determining minute traces of sulphur in obscure combinations. The use of bromine water as an absorbent and oxidizer presents some material advantages over using other oxidizing agents because it is volatile and can easily be expelled from its combination with bases. It is especially recommended by some of the older workers and by Fresenius* for breaking up complex forms of sulphur and carbon. By taking the gas direct into the absorbing solutions there is no fear of losing any sulphur as the case would be if the sample had been collected over water or mercury and afterwards tested. In using this metal, hydrogen sulphide would enter into a chemical combination with it, and impair the results.

Before beginning a set of determinations on producer gas, a blank determination should be run on air, proceeding identically as if a gas sample was being examined. The object of running a blank test is to ascertain the purity of the reagents employed and if traces of sulphur are found, to make due correction in the final result.

*Fresenius, Zeitschrift, XIII. 37.

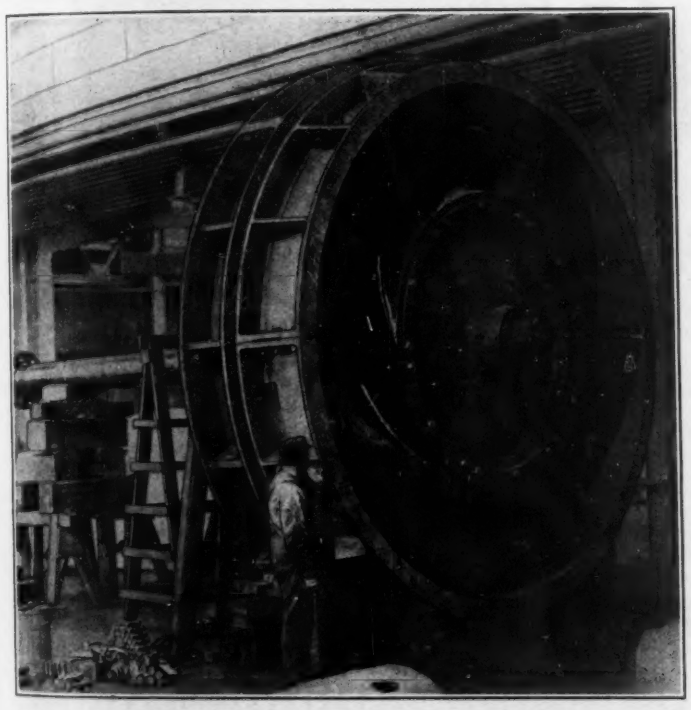

FIG. 6. PROPELLER WHEEL OF PUMPS FOR KINNICKINNIC RIVER FLUSHING PLANT.

100-TON THREE-CYLINDER TANK LOCOMOTIVES FOR SWITCHING WORK.

The increasing use of gravity switching in yards has led to the introduction of some very heavy switching engines, designed to push very long trains up the grade to the hump or summit, beyond which they run by gravity to the several classification tracks. The same development is apparently taking place in England, and in the May number of "The Railway Engineer" (of London) we find particulars of some new yard switching engines weighing nearly 100 gross tons. These are tank engines of the 0-8-4 class, having eight driving wheels under the boiler and firebox, and a trailing truck under the cab and coal bunker. These engines are for handling heavy coal and freight trains in the Wath yards of the Great Central Ry., and are required to push trains of 80 loaded cars (1,200 gross tons) up a grade of 0.68% leading to the summit.

A special feature of these engines is the use of three high-pressure cylinders in order to obtain a more uniform turning movement, the cranks being set at 120°. This gives high tractive power at moderate speed and diminishes the tendency to slip, while in starting the train or pushing it up the grade under unfavorable conditions as to rail, etc., the engine will be able to exert its maximum power at any time. The cylinders are slightly inclined, and the inside cylinder drives the second axle, while the outside cylinders drive the third axle. A steam reversing gear is used, and brakes are applied to all the driving and truck wheels, so that the great power of the engine is under immediate control. The engine can exert a drawbar pull of 13 tons for speeds as high as ten miles per hour. Interchangeability of parts is a feature of the motive power equipment of this road, and these engines have the boilers of the Atlantic (4-4-2) passenger engines, and the wheels and outside running gear of the eight-coupled (0-8-0) freight engines, while the inside running gear is that of the six wheeled (0-6-0) freight engines. The water is carried in side tanks and in a water bottom extending under the cab and coal bunker.

These interesting engines were built by Beyer, Peacock & Co., of Manchester, England, to the designs of Mr. J. G. Robinson, Chief Mechanical Engineer of the Great Central Ry. Their dimensions are as follows:

Driving wheels (8)	4 ft. 8 ins.
Truck wheels (4)	3 ft. 7 ins.
Wheelbase, driving	17 ft. 1 ins.
Truck	7 ft. 6 ins.
Total	30 ft. 8 ins.
Length over all	45 ft. 0½ ins.
Weight, on driving wheels	165,760 lbs.
On truck	49,868 lbs.
Total	215,628 lbs.
Cylinders (3)	18 × 26 ins.
Boiler, straight top; diameter	5 ft. 0 ins.
Working steam pressure	200 lbs.
Firebox	8 ft. 0 ins. × 3 ft. 3 ins.
Tubes, 221; diameter, 2 ins.; length	15 ft. 4½ ins.
Heating surface; tubes	1,778 sq. ft.
Firebox	153 sq. ft.
Total	1,931 sq. ft.
Grate area	26 sq. ft.
Water in tanks	3,600 gallons
Coal in bunker	5 tons

AN INTERLOCKING DEVICE FOR LIFT-RAILS is in trial service on the Thoroughfare drawbridge, Atlantic City, N. J., on the West Jersey & Seashore R. R. electric line. This bridge will be remembered as the scene of a disastrous derailment in October, 1906. At that time an eastbound electric train reached the draw shortly after the latter had given passage to a vessel. The bridge had been properly closed, and the rail-lifts and end lock, with which the semaphore signals were interlocked, had gone into place, thereby allowing the signals to clear. However, it is believed that one of the lift rails had caught on the edge of its guide instead of dropping into the guide-socket. This occurrence was possible as the lift-rails were not bolted to the lifting device, but merely rested on the cross-bar of the latter. When the train came on, the signals being cleared, it left the track, and fell over into the water (the bridge is a deck structure), presumably as the result of striking the projecting rail end. Some 50 lives were lost. The device now on trial is adapted to prevent the recurrence of such an accident. It consists of a detector interlocked with the signal levers, of such arrangement as to permit clearing the signals only after the lift-rails have actually descended to their proper level. On either end face of the draw is fitted a lock plate extending the entire width of the bridge, adapted to move horizontally in guides. Each lift-rail bears a clamp, just over this lock-plate, which clamp has at its lower prolongation an L-shaped slot engaged by a dog in the lock-plate. When the lift-rails are down, these dogs lie in the horizontal part of the slot. Before they can be lifted the semaphores must be set to the stop indication, releasing a lever whose movement draws the lock-plate over until the dogs reach the vertical branches of the slots. The bridge operator can then lift the rails, uniatch the bridge and swing it. On the reverse motion, the bridge must be latched, the lift-rails dropped until the dogs stand opposite the horizontal part of the slots, and the lock-plates then drawn over to lock the rails, before the semaphores can be cleared. The lock lever cannot be operated, and consequently the signals cannot be cleared, if the rails are more than ⅛-in. above their proper level.

The bridge has also been equipped with inside guard-rails, in addition to the outside guard-timbers.

SPECIFICATIONS FOR THE MAIN DAMS, ASHOKAN RESERVOIR, NEW YORK CITY WATER SUPPLY.

The specifications and contract drawings for the 120,000,000,000-gal. Ashokan Reservoir, about to be built by the Board of Water Supply of the City of New York, have just been made public. The main features of this reservoir and the dams which will form it were described in our issue of May 9, 1907, and the principal quantities involved in the construction of the main dams were given in a note on page 47 of our issue of July 11. Some facts regarding the dams and the conditions under which they are to be constructed have been extracted from the specifications and are given below. Copies of the plans and specifications, it may be added, can be obtained for $10, by addressing the Board of Water Supply, 299 Broadway, New York City.

As many of our readers know, the Ashokan Reservoir is to form a part of the additional water supply for New York City to be drawn from streams in the Catskill Mountains. The works contemplated will have a daily capacity of not less than 500,000,000 gals., and, according to the preliminary estimate, will cost $162,000,000. The Ashokan Reservoir will be about 12 miles in length and will be connected by the Catskill Aqueduct, 82 miles long, with the Kensico storage reservoir near White Plains, N. Y. The works will also include a filtration plant near Scarsdale, and the Hill View distributing reservoir in Yonkers, just north of the New York City line.

The Ashokan Reservoir will be formed, as shown by the large map in our issue of May 9, by constructing a high masonry dam, with earth wings or extensions, across Esopus Creek, and also by constructing earth dams across minor streams and across depressions in the reservoir basin. A section of the masonry dam and also of the principal earth dam was given in our issue of May 9. Bids for the construction of these main dams will be received on August 6, 1907. Messrs. J. Edward Simmons, Charles N. Chadwick and Charles A. Shaw are the Commissioners of the Board of Water Supply; Mr. J. Waldo Smith, M. Am. Soc. C. E., is Chief Engineer; Mr. Alfred D. Flinn, M. Am. Soc. C. E., is Engineer of the Headquarters Department; Mr. Carleton E. Davis, M. Am. Soc. C. E., is Engineer of the Reservoir Department of the Board.

GENERAL FEATURES.

As a matter of convenience and fairness in making preliminary estimates, the specifications provide that "accepted materials delivered on the site of the work but not incorporated in the work" shall be allowed for at certain stipulated prices, these allowances to be taken into account, of course, in the final settlement. No allowances for plant are to be included in partial estimates.

An unusual feature of the specifications is a provision for interest at 4½% per annum on all partial payments not met by the city within 30 days, and also on the final payment in case it is not met by the city within 40 days from the time it is due under the terms of the contract.

The use of the planimeter in estimating quantities is provided for in the specifications as follows:

Sec. 12. For the estimating of quantities in which the computation of areas by geometric methods would be comparatively laborious, it is stipulated and agreed that the planimeter shall be considered an instrument of precision adapted to the measurement of such areas.

MEDICAL AND SANITARY REQUIREMENTS.

The sections of the specifications relating to medical and surgical attendance, sewage and garbage disposal and other sanitary precautions are of sufficient interest to warrant quotation:

Sec. 22. The Contractor shall retain the services of one or more qualified medical and surgical practitioners, who shall have the care of his employees, shall inspect their dwellings, the stables and the sanitaries at least once a week, or oftener, if the health conditions of any portion of the camp shall make more frequent inspection desirable, and shall supply medical attendance and medicines to the employees whenever needed. The Contractor shall provide one or more buildings, properly fitted for the purpose of a hospital, with facilities for heating and ventilating in cold weather and for screening and ventilating in warm weather. These hospitals shall have an ample number of beds to properly care for sick or injured employees, and shall be provided with all articles necessary for giving "First Aid to the Injured," as well as with all necessary medicines and medical appliances for the proper care of the sick and injured. Another suitable building shall be provided and equipped as a contagious hospital, and any employee, who shall be found to have a contagious or infectious disease, shall be at once removed from the camp to this hospital, and there properly isolated and treated. The Contractor shall give the Engineer satisfactory assurance that the above medical and hospital arrangements have been made.

Sec. 23. Sanitary conveniences for the use of all persons employed on the work shall be constructed and maintained by the Contractor in sufficient number, in such manner and at such places as shall be approved. All persons connected with the works shall be obliged to use these conveniences. The sanitaries shall be connected with one or more disposal plants, where all sewage shall be treated, so as to yield a reasonably clear and colorless effluent, free from disagreeable odor. Samples of the effluent shall show no increase in the oxygen consumed after being kept three days at a temperature of 80° F. In addition to the above, pan-closets shall be provided and properly cared for at convenient points on the parts of the work remote from the disposal plants, whenever necessary for the prevention of nuisances. The Contractor shall rigorously prohibit the committing of nuisances within the limits of the work.

Sec. 24. Garbage, both liquid and solid, shall be promptly removed from the buildings and immediately placed in approved tight receptacles of sufficient capacity for about one day's ordinary production. At least once in 24 hours all such garbage shall be incinerated or otherwise thoroughly and satisfactorily disposed of so as not to create a nuisance.

Sec. 25. The sanitary precautions, including those to prevent contamination of the waters of the Esopus Creek, and the care of the employees shall at all times be satisfactory to the Engineer, to the Department of Health of the City of New York, and to the State Board of Health. The Contractor shall promptly and fully com-

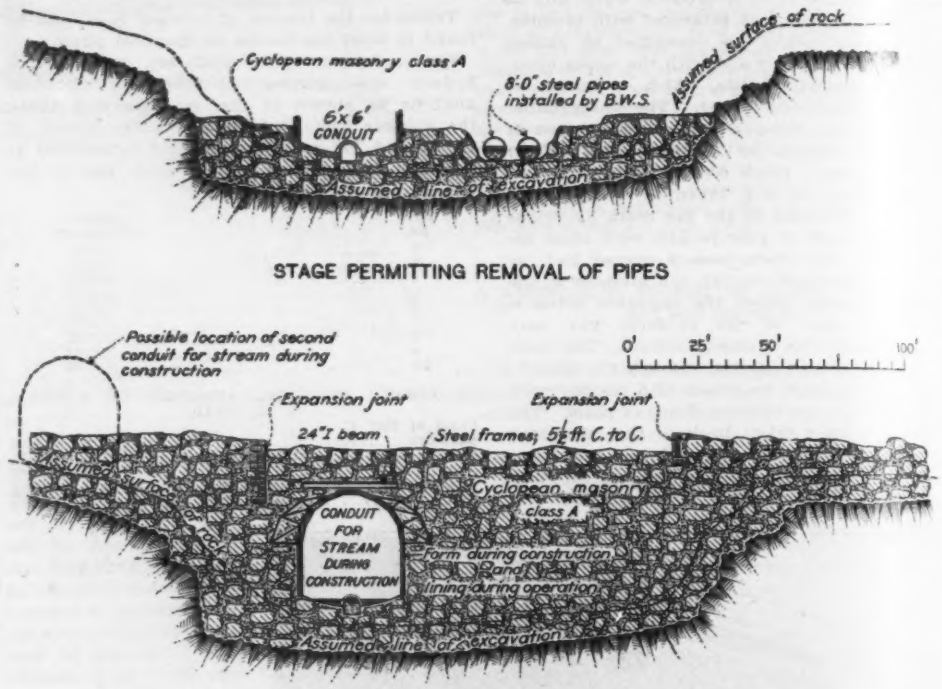
Cyclopean masonry class A
6'x6' CONDUIT
8'-0" steel pipes installed by B.W.S.
Assumed surface of rock
Assumed line of excavation
STAGE PERMITTING REMOVAL OF PIPES
Possible location of second conduit for stream during construction
0' 25' 50' 100'
Expansion joint
Expansion joint
24"I beam
Steel frames; 5 ft. C. to C.
Cyclopean masonry class A
CONDUIT FOR STREAM DURING CONSTRUCTION
Form during construction
Lining during operation
Assumed line of excavation
PIPES REMOVED, CONDUIT COMPLETED

FIG. 1. OPENINGS THROUGH OLIVE BRIDGE DAM, ASHOKAN RESERVOIR, FOR CONTROLLING STREAM FLOW DURING CONSTRUCTION.

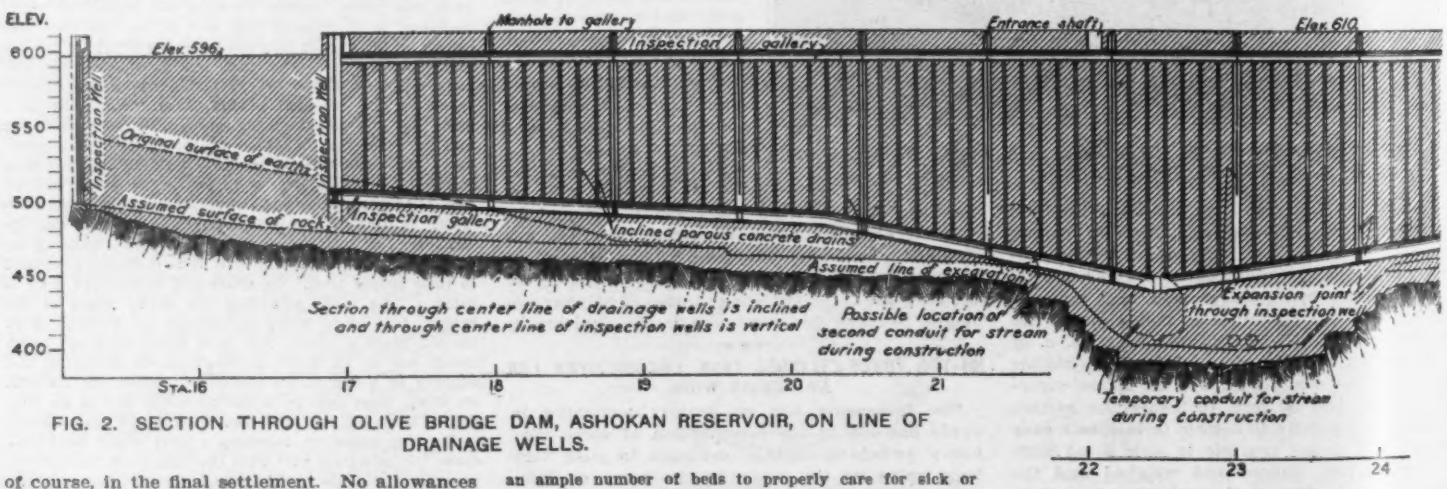

FIG. 2. SECTION THROUGH OLIVE BRIDGE DAM, ASHOKAN RESERVOIR, ON LINE OF DRAINAGE WELLS.

ply with all orders and regulations in regard to these matters.

* * * * * * * * *

Sec. 68. Excavations shall be made from within and around privy vaults, cesspools, barnyards, poultry yards, and similar places within the area covered by this contract, and disposal of these excavated materials shall be made outside the reservoir at the place and in the manner directed. Such material as required shall be properly disinfected. For excavated material specified in this section, payment shall be made at the price stipulated for earth excavation in Item 4.

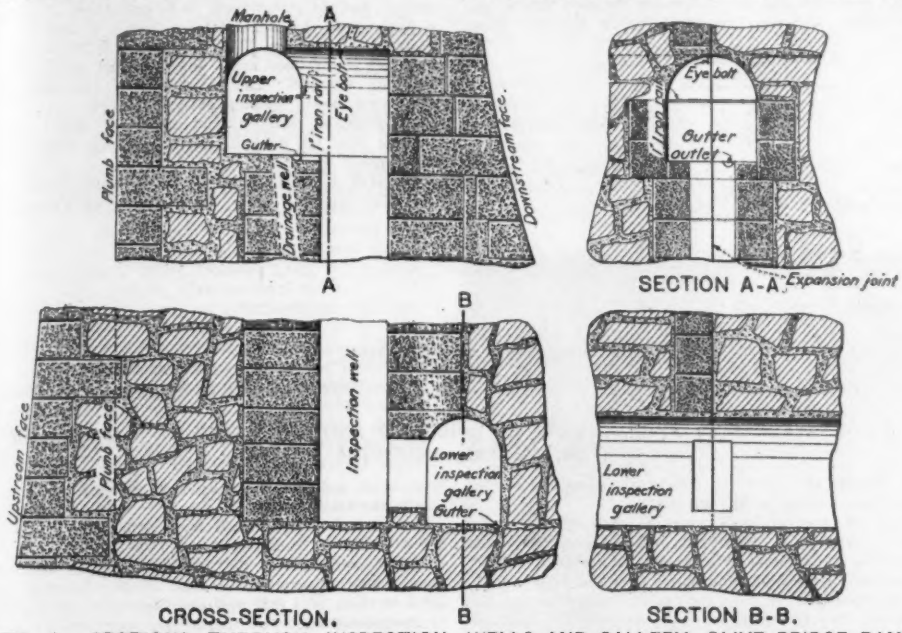

FIG. 3. SECTIONS THROUGH INSPECTION WELLS AND GALLERY, OLIVE BRIDGE DAM, ASHOKAN RESERVOIR.

Very few contract specifications include a section like the following, which looks to preserving trees for future landscape effects:

Sec. 33. Many trees on the city's land are to be preserved as parts of the landscape treatment of the completed works. Only such trees as will be permitted from time to time shall be cut down or injured. The Contractor shall satisfactorily protect until the completion of all operations under this contract, such trees as shall be designated.

STREAM CONTROL.

The general method of stream control during the construction of the Olive Bridge Dam is illustrated by Fig. 1. The drainage area of this dam is about 240 sq. mi. It is estimated that flood flows of 15,000 cu. ft. per sec. may be expected each year, and that a maximum of at least 38,000 cu. ft. might be reached and might even be exceeded. The Board of Water Supply is installing two cofferdams at the site of the dam, and laying two 8-ft. steel pipes through and between them. These are designed to carry the ordinary stream flow until the masonry reaches their level, whereupon it will be diverted to the large conduit formed in the masonry itself; all as shown in Fig. 1. A second conduit for stream control may be required at the discretion of the engineer.

MASONRY.

The masonry structures for the most part will be cyclopean, "consisting of concrete into which stones of various sizes, up to the largest that can be conveniently handled," will be embedded. The main dam will be faced with concrete blocks and the same kind of material will be used at the expansion joints and as a lining for the inspection wells. Figs. 2 and 3 show the details of the novel system of drainage and inspection wells and the inspection gallery designed for the Olive Bridge Dam, and Fig. 4 shows a horizontal section of the expansion joint. Regarding these features of the structure, the specifications may be quoted as follows:

Sec. 132. The masonry portion of the Olive Bridge Dam will be built principally of cyclopean masonry founded upon solid rock. It will be about 1,000 ft. long on top and its maximum height may exceed 230 ft. At such intervals and depths as shown on the drawings or directed, expansion joints, normal to the dam line, shall be formed by building vertical faces of concrete blocks; each such face shall be coated with acceptable material to prevent adhesion to the masonry on the other side of the expansion joint; otherwise, these blocks shall be carefully bonded to each other and to the adjoining masonry. In connection with the expansion joints, inspection wells will be constructed as shown on the drawings. These wells will not be filled under this contract, but may be filled with masonry or clay by the city before the completion of the work under this contract. The expansion joints will divide the masonry dam into sections, and as the work progresses alternate sections may be carried ahead of the intervening ones, the expansion joint blocks serving as the forms for the adjacent sections. Derricks may be placed on such higher sections for use in placing masonry in lower sections.

* * * * * * * * *

Sec. 134. A drainage system shall be built into the masonry dam, approximately as shown on the drawings, consisting of an upper and a lower gallery between which shall be built inclined drainage wells formed by laying up hollow, porous concrete blocks, to be spaced as shown on the drawings, or as otherwise directed. The wells formed by the blocks shall be kept clean and free from mortar, and have smooth continuous surfaces and a uniform diameter. To maintain the wells in this condition and provide against accident, each shall be constantly protected by a metal grating or other acceptable cover that can be moved as the work progresses. The Contractor shall provide all centering required, and perform all work necessary to the completion of the drainage system without compensation other than that bid for the drainage blocks under Item 22, and the cyclopean masonry Class A, under Item 20.

CEMENT AND CONCRETE.

The kinds and quality of cement are specified in general terms as follows:

Sec. 138. All cement used in the work shall be true Portland cement of well-known brands which have been in successful use for large engineering works in America for not less than five years, and which are manufactured at works which have been in successful operation for at least two years. The brands shall be acceptable, and before beginning to furnish cement the Contractor shall inform the Engineer what brands he proposes to use. Unless otherwise permitted, not more than three brands shall be used in the whole work, and only one brand shall be used at the same time in any section of the work, excepting as permitted.

Sec. 139. All cement shall be dry, finely ground, and free from lumps, caking or water marks. By Portland cement is meant the finely pulverized product, resulting from the calcination to incipient fusion of a properly proportioned intimate mixture of argillaceous and calcareous materials, to which no addition greater than 3% has been made subsequent to calcination.

The cement tests will be made in general conformity to the well-known recommendations of the Committee of the American Society of Civil Engineers.

The general proportions for concrete will be, 1 volume of cement to 8 volumes of "sand or screenings, and gravel or crushed stone," but some leaner concrete may be required. In measuring the cement, 105 lbs. will be considered 1 cu. ft. Mechanical mixers of an approved type will be used for mixing the concrete, "except that, if permitted, relatively small quantities may be mixed by hand in a satisfactory manner." The concrete must be deposited in place in batches of not more than 1 cu. yd. each. The general specification of concrete blocks is as follows:

Sec. 188. Facing and stair blocks are to be of dense concrete, carefully cast to obtain smooth faces uniform in appearance where exposed. Expansion joint blocks are to be dense and to have one or two plane smooth faces. Blocks for drainage ducts are to be of specially proportioned aggregates, designed to obtain a maximum porosity consistent with the necessary strength, but will have no faces which need be more than ordinarily smooth. The ducts in the gate-chamber for drainage and for the gaging wells are to be rectangular blocks with a cylindrical bore of smooth surface.

* * * * * * * * *

Sec. 194. If so ordered, steel rods, to be paid for under Item 32, shall be embedded in the concrete blocks, as directed, to reinforce the blocks and provide means for lifting or anchoring them.

Reinforced concrete will be used for some of the drainage features of the main dam and for covering over wells and chambers in the gate-chamber.

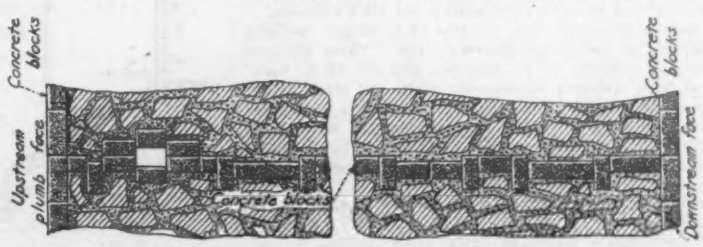

FIG. 4. PART HORIZONTAL SECTION OF EXPANSION JOINT, OLIVE BRIDGE DAM, ASHOKAN RESERVOIR.

INDUSTRIAL VENTILATION is presented in a recent article by Miss Gertrude Beeks, Welfare Secretary of the National Civic Federation. Extracts are furnished us by the B. F. Sturtevant Co., of Hyde Park, Mass.

Systems of ventilation which permit a complete change of air in the workrooms at least every fifteen minutes are already installed in many modern structures. Employers are beginning to realize the desirability of going to the expense of installing such systems in old buildings. In one notable case the cost of installation was six thousand dollars, but the reduction thereafter of the percentage of absences because of illness was so great that the employer was compensated for the outlay. It was also found that while previously the employees were likely to become stupid the latter part of the afternoon, the new system maintained alertness during the entire day. It has been found advantageous to install, even in the old cotton mills, exhaust systems for the removal of the lint resultant from the first processes of manufacture.

In the foundry, where the pipes which are used in the winter for heating serve to bring in the cool air in the summer, great comfort is afforded the moulders. Galvanized iron pipes carry fresh air to the faces of the men employed in rolling mills. Previously, in very hot weather, the men were frequently overcome, and sometimes it was necessary to shut down the entire mill, the workmen thereby losing their wages and the company the output. Where these ventilating systems have been installed, not a single hour's time has been lost because of the excessive heat. In the case of stationary engineers and firemen, the pipes for forced ventilation have been brought out above the furnace doors to prevent the firemen from baking their faces when "hauling the fires." In numerous cases their comfort in working hours has been increased by exhausting the foul, hot air and throwing fresh air into the furnace and boiler rooms. In many isolated power plants this is seriously needed because the rooms are located in the sub-cellars or interiors of structures.

Where it is necessary to humidify the air in the textile industry, employers have found that the cold water spray provides an atmospheric condition much more comfortable for the operatives than the steam spray during the summer season, and that heat is not essential to the successful manufacture of cotton goods. In a watch factory fresh air, which has been forced through sheets of water, is conducted through pipes to the faces of the young women who sit in front of the ovens baking the faces of the watches.

THE LARGEST COPPER SMELTING PLANT IN THE WORLD.*

The famous Washoe smelter of the Anaconda Copper Mining Co. is located about two miles east of Anaconda, Mont. Being on a hillside, it was possible to make the level of delivery of the product of one building the level of the charge floor of the next succeeding building. This is shown by the diagrammatic section, Fig. 1. The ore comes principally from the Butte district, 28 miles, and is hauled by the Butte, Anaconda & Pacific Ry. in trains of 50 bottom-dump 50-ton cars to the yards at East Anaconda. There they are split up, the cars going to the concentrator and sampling mill ore bins, or to the storage bins.

Sampling Mill.—This is a wooden building, 40 × 60 ft., and six stories high. It consists of two complete sections, each section having a capacity of 1,800 tons in 24 hours. The ore to be sampled is taken from the sample bins by an electric locomotive and dropped into bins feeding the crushers. The discharge of these crushers is elevated to the top of the building by means of bucket elevators. The stream of ore is cut four times by Brunton automatic samplers, cutting out one-fifth of the amount each time and discarding four-fifths,—the final result being 3.2 lbs. for each ton of ore crushed. The discard from the sampling machines is elevated and dumped into concentrator ore bins, or, if it is first-class ore, it is sent to the storage bins at the blast furnaces. The final sample is quartered by a Brunton quartering shovel. The resulting sample is dried on a steam drier, ground in an Engelhardt sample grinder, bucked so as to pass through a 100-mesh sieve and put up in three separate sample packages. One goes to the laboratory for analysis, one to the owner of the ore, and one filed away for use in case of dispute.

Concentrator.—This consists of two steel and wood buildings, each 255 × 350 ft., and containing four complete sections, or eight in all. Each section is equipped with the same kind of machinery (crushers, rolls, jigs, etc.), and will handle 1,100 tons of ore in 24 hours. A system of launders carries the concentrates to the settling tanks at the foot of the concentrator building. The tank house is 70 × 670 ft., and contains nine settling tanks for each section. These tanks are 19 × 19 ft., and 15 ft. high. Each has a capacity of 420 tons of concentrates. These nine tanks are divided as follows: six for first settlement of the concentrates, and three for second settlement of the concentrates, for settling the overflow of the first tanks. The overflow from the second settlement tanks goes to three large tanks common to all sections in that half of the mill. The overflow from these tanks goes to the slum pond with the slum water from all the settling tanks and Wilfley tables. The concentrates caught in the first settlement tanks are called "fine concentrates," those of the second tanks "second settlement concentrates," and those of the third tanks "tank slum." The first two products are treated in the roaster building, the third at the briquette plant.

There are six slum ponds of different sizes, but averaging about 300 × 630 ft., and the slum water, containing the greater metal values coming from the concentrator, goes to these ponds for settlement. When a pond is full, the water is diverted to an empty pond, and as much water drained off from the full pond as possible. The pond is then excavated by one of two Lidgerwood traveling cableways, each having a 5-ton bucket. The slum is piled outside of the pond and allowed to drain and dry, and from these piles it is taken by cableway and dropped into a hopper on trucks, from which it runs into the cars beneath and is taken to storage bins for use at the briquette plant. The slime water containing the least values is used for condensing purposes and for sluicing slag at the reverberatories and blast furnaces.

Roaster Building.—This contains 64 McDougal calcining furnaces of the Evans-Klepetko type. These furnaces have six hearths, 16 ft. diameter, and are 18 ft. high; they have revolving water-cooled shafts and arms, driven by suitable gearing from the top. No fuel is used other than the sulphur in the concentrates, the burning of which furnishes sufficient heat to do the calcining, except on occasions when the furnace is not hot enough to ignite the sulphur, at which times fine coal is fed. Each furnace is capable of handling 45 tons of material in 24 hours.

Reverberatory Buildings.—This plant consists of two steel buildings, 183 × 225 ft., each containing four coal-fired furnaces, the hearth dimensions of which are 19 ft. in width and from 102 ft. to 116 ft. in length. The grate is 8 × 16 ft., and the smelting capacity 300 tons per 24 hours, on natural draft. The flame, after leaving the furnace, passes through two 375-HP. Stirling boilers, in tandem, which reduce the temperature of gases going to the main flue to about 600° F. By this means 600 B. HP. are obtained from each furnace from the waste heat.

The slag is skimmed from the reverberatories twice in eight hours. It is allowed to accumulate until its depth is from 3 to 4 ins. above the skimming plate in front of the furnace, and then skimmed into a stream of slum water, which granulates and sluices it through a cast-iron-lined launder to the slag dump. By allowing the slag to accumulate in the furnace in this manner it is possible to skim the furnace very rapidly, as much as 60 tons of slag being removed in 20 minutes. By this method the actual use of a rabble to "pull" the slag is avoided, the rabble being used to keep the "bay" clear of floating pieces of unfused silica and to prevent the flow being more rapid than the water can handle properly. The matte is kept down some distance below the skimming plate, making it impossible to "pull" out any of the matte, thus avoiding explosions. The matte is tapped from the side of the furnace, through copper tap-hole plates, and run through cast-iron launders, lined

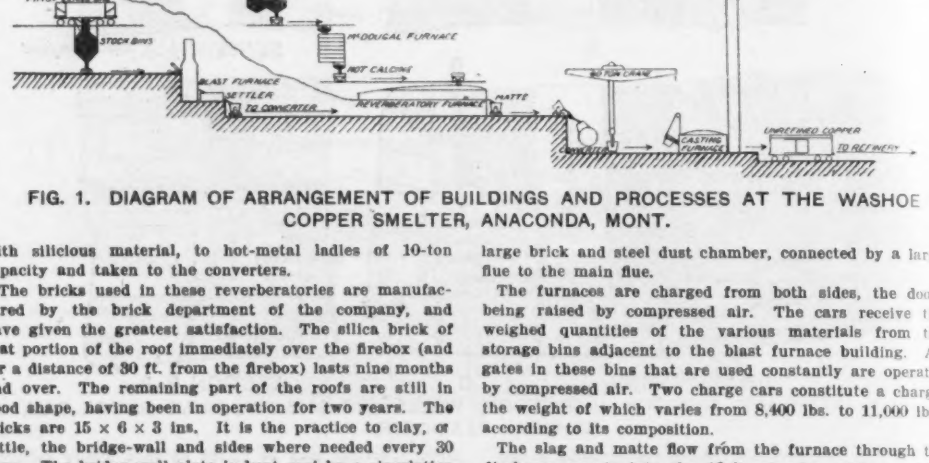

FIG. 1. DIAGRAM OF ARRANGEMENT OF BUILDINGS AND PROCESSES AT THE WASHOE COPPER SMELTER, ANACONDA, MONT.

with silicious material, to hot-metal ladles of 10-ton capacity and taken to the converters.

The bricks used in these reverberatories are manufactured by the brick department of the company, and have given the greatest satisfaction. The silica brick of that portion of the roof immediately over the firebox (and for a distance of 30 ft. from the firebox) lasts nine months and over. The remaining part of the roofs are still in good shape, having been in operation for two years. The bricks are 15 × 6 × 3 ins. It is the practice to clay, or fettle, the bridge-wall and sides where needed every 30 days. The bridge-wall plate is kept cool by a circulation of air by a pipe connection to the main flue.

Briquette Plant.—This contains four Chambers Brothers end-cut, auger-type brick machines, each having a capacity of 700 tons of briquettes in 24 hours. The briquettes are made of fine concentrates, fine first-class ore, pond slum, and fine coke from the reverberatory ashes. These materials are conveyed from the storage bins by belt conveyors to a pug-mill, from which they discharge into the brick machine proper, where they are further mixed and forced through a former by the auger of the machine in a continuous bar. This bar is cut into briquettes, weighing about 10 lbs., by a revolving cutter peculiar to this type of machine. The briquettes are conveyed by a series of belt conveyors to storage hoppers, from which they are loaded into blast furnace cars as part of the charge.

Blast Furnaces.—The blast furnace building is of steel construction, 82 × 269 ft., and contains three furnaces; two are 51 ft. long and the other 87 ft. long. All have a width of 56 ins. at the tuyeres. The smaller furnaces have a capacity of 1,600 tons, the larger 3,000 tons of

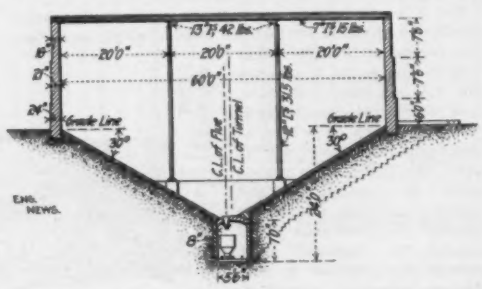

Fig. 2. Single-Compartment Smoke Flue from Furnaces to 300-ft. Smokestack.

charge in 24 hours. The bottom of the center of the furnace is of silica brick, laid on water-cooled cast-iron plates mounted on cast-iron columns, and has a gradual slope to each discharge spout. The 87-ft. furnace has three discharge spouts and three settlers, but is otherwise built in the same manner as the 51-ft. furnace. The 51-ft. furnace has eighty-eight 4-inch tuyeres, and the 87-ft. furnace has 150.

The type of furnace used is the Mathewson patent blast furnace. It is very successful in operation and much easier to handle than the old style furnaces. Its advantages are: That it has increased hearth area with but two ends to bind and hold the crusts. Any crusts forming on the sides can be readily got rid of by allowing the furnace to run down, the crust either dropping or being readily barred. It has smaller radiating surface for the same hearth area than the smaller furnaces, uses less coke, makes a flexible unit (as any part of the furnace can be handled as the case demands), and is susceptible of repairs without shutting down the entire furnace. Leaking water jackets may be replaced without shutting down the furnace, thereby saving considerable time. It takes from six to eight hours to change a jacket. The procedure is to shut off the tuyeres on the jacket to be changed and the one opposite, allowing the water to circulate until all buckstays, tuyere pipes, etc., are removed, and the jacket ready to be pulled out. This fills a wall inside the jacket strong enough to hold the contents of the furnace. The new jacket is placed in position, all connections made and the blast turned on and smelting resumed. The entire end of one furnace has been shut down, jackets changed, furnace cleaned out and operations resumed, and during all this time (extending over ten days to two weeks) the other half of the furnace was in operation.

The 51-ft. furnace has three 7-ft. 45° unlined steel flues; the 87-ft. has five flues. All the flues discharge into a large brick and steel dust chamber, connected by a large flue to the main flue.

The furnaces are charged from both sides, the doors being raised by compressed air. The cars receive the weighed quantities of the various materials from the storage bins adjacent to the blast furnace building. All gates in these bins that are used constantly are operated by compressed air. Two charge cars constitute a charge, the weight of which varies from 8,400 lbs. to 11,000 lbs., according to its composition.

The slag and matte flow from the furnace through the discharge spouts into the 16-ft. circular settlers, which are made of ½-in. steel plates lined with 12-in. silica brick. The slag overflows and is granulated by slum water from the concentrator, and is carried off in launders lined with cast-iron to the dump. The matte is tapped from the settler into the 10-ton. hot-metal ladles, and taken to the converter plant while still molten.

Converters.—The converter building, including the converter lining plant, casting furnaces and converters, is 176 × 416 ft., and is constructed of steel. The converters are the horizontal barrel type, 8 ft. diameter and 12 ft. 6 ins. long, and are operated hydraulically. The building is equipped with two 60-ton electric traveling cranes; one is for handling the converters when they are in need of replacement and for other work in connection with the lining department, the other is for handling slag and copper from the converters. There are also two 15-ton electric cranes in the casting department.

The matte is brought from both blast furnace and reverberatory buildings to the charge floor of the converter building, which is 23 ft. above the operating floor. The matte is poured from the ladle into a launder, the end section of which is pivoted so that it can be turned out of the way when the converter is filled. The converter is filled in a nearly vertical position with the air blast on. Seven tons of matte per charge is used whether the converter is freshly lined or not, and the charge is finished to blister copper in the same converter.

The slag from the converters is poured into unlined cast-steel ladles and taken by the crane to a casting machine of the platform conveyer type, having pressed steel molds. This slag ladle is placed in a hydraulic cradle from which the slag is poured into the molds, chilled by sprays of water and conveyed to a steel bin outside of the building, from which it is loaded into cars and transferred to the storage bins for blast furnace use. The blister copper is poured into a sheet steel clay-lined ladle and taken by the crane to a hydraulic cradle, from which it is poured into the casting surface.

The converter lining material is highly silicious ore, having gold and silver values, and pond slum is used as a binder. The material is crushed by a Blake crusher and fine rolls, sized by trommels and sent to the bins, which feed four Carlin 7-ft. grinding and mixing pans. Here it is ground and mixed with pond slum to the proper consistency and then transferred to the converter, where it is tamped around a steel form by a special Ingersoll-Sergeant tamping machine, 5-in. diameter and 20-in. stroke. This tamping machine is supported by a revolving jib crane, the vertical motion of which is controlled hydraulically. After lining, the converter is removed to the drying stand by the crane.

Casting.—There are three casting furnaces, two having a capacity of 95 tons and one 110 tons; two of these are

*From a pamphlet prepared by members of the staff of the Anaconda Copper Mining Co. for private distribution.

in operation all the time. The copper is poured in at the side, and as soon as the furnace contains 50 or 60 tons, the oxidation by 90-lb. air pressure is commenced. When the furnace is full, the slag is removed and oxidation is completed; it is then "poled" back to the desired pitch and cast. The casting machine is a platform conveyor with the molds attached, and operated hydraulically. The molten copper is run into a suspended ladle, from which it is poured hydraulically into the mold on the machine. When a mold is full the ladle is dropped to a horizontal position and the conveyor is moved so as to bring the next mold into position, and the process is repeated. This machine is capable of casting 25 tons per hour. The copper is chilled by a spray, and when "set" is dumped from the mold onto a platform conveyor, operating through a tank of water. It is then weighed and shipped to eastern refineries.

Flues and Stack.—There is an elaborate flue arrangement, especially noted for its immense size. The three principal flues (the blast, roaster and reverberatory) are 20 ft. wide and 15 ft. high, of brick and steel construction. The converter flue consists of two 7 × 7-ft. flues. The blast, roaster and converter flues connect with their respective dust chambers; the reverberatory flue connects with the furnaces direct. The lengths of the flues are as follows: Blast furnace, 1,653 ft.; roaster, 488 ft.; converter, 703 ft.; reverberatory, 842 ft.

The flues all merge into one main flue. For the first 1,200 ft. this is 60 ft. wide, with side walls 20 ft. high, and the bottom sloping at 30° from either side. This is shown in Fig. 2. The roof is of I-beam and brick arch construction. The remaining distance to the stack is 1,122 ft. of 120-ft. flue, having two parallel sections similar to Fig. 2. This portion of the flue has a roof of No. 9 sheet steel. The stack is 300 ft. high, with an inside diameter of 30 ft. The top of this stack is 932 ft. above the surrounding valley.

The flue dust is drawn off through hoppers, spaced every 10 ft. in the tunnel, as shown in Fig. 2, into cars operated by the gravity system from a set of drums placed immediately behind the stack. When the cars are loaded they are sent to the lower end of the main flue and elevated to the adjacent flue-dust bins. There are two sets of bins here, one for the flue dust containing the desired percentage of arsenic for the arsenic plant, the other for flue dust to go directly to the reverberatories.

The equipment of the local or industrial railway system consists of 17 H. K. Porter & Co.'s air locomotives, weighing from 12½ to 22 tons, each, and 240 cars of various kinds. The locomotives operate with 900-lb. air pressure in the receivers, which is reduced by means of reducing valves to 150 lbs. for use in the cylinders. There are 48 miles of standard gage tracks in the works. The charging stations are placed at convenient points throughout the works, and are fed by an extensive piping system. The locomotives are charged about every 20 minutes,—this varies according to the nature of the work; it takes about two minutes to charge. This railway handles about 13,000 tons of material each 24 hours.

The following figures are of interest:

	Per 24 Hrs.
Amount of ore that can be treated in 24 hours	10,000 tons.
Lime rock from adjacent quarries	2,300 "
Coke used	650 "
Coal for reverberatory use	500 "
Coal for power use	500 "
Water, per minute	35,000 gals.
Men employed in and around Anaconda	3,000
Monthly payroll for above	$300,000

MINERAL PRODUCTION IN THE UNITED STATES in 1906 is the subject of preliminary estimates put out by the U. S. Geological Survey. Some of the principal items in the estimate are as follows: Pig iron, 25,307,000 long tons, valued at $505,700,000; aluminum, 14,910,000 lbs., at $4,263,000; cement, 51,000,445 bbls., valued at $55,303,000, of which 46,463,424 bbls., at $52,447,000, were Portland cement. Of minor interest it may be noted that the total production of grindstones is valued at $745,000, and of whetstones and oilstones at $268,000.

COMPETITIVE DESIGNS FOR CANADIAN GOVernmental buildings have been submitted to the number of thirty. This competition was open to any Canadian architect and offered four prizes of $8,000, $4,000, $2,000 and $1,000 for the four best designs for a new governmental block adjoining the present Parliament buildings and for a new Justice Building, the total cost of the new work running well above $3,000,000. The departmental block is to be over 1,000 ft. long, five stories high and will contain above 360,000 sq. ft. of floor space. The Justice Building, which will accommodate the Department of Justice and all the higher courts, is to be three or four stories high and will contain about 60,000 sq. ft. floor area. As a limit to the competitors' ideas of material and ornamentation, it is specified that the latter building shall not cost more than 35 cents a cubic foot. The Government is very much gratified that so great an interest should be displayed in the contest at a time when such activity prevails in the building trade in Canada and the local architects are so busily engaged in outside work.

JOHN A. BRODIE, PRESIDENT OF THE INCORPORATED ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS.

The Association of Municipal and County Engineers is a British society which has no counterpart in America. Our nearest approach to it is the American Society of Municipal Improvements. Our society, however, is relatively small, meets only once a year, and does little for its members or for anyone else meanwhile. The British association, besides a general annual meeting, holds many district meetings, and also holds "qualifying examinations for young municipal engineers."

We present herewith a portrait and biographical sketch of Mr. John A. Brodie, M. Inst. C. E., the newly elected President of the association named. For the portrait we are indebted to our London contemporary, "The Surveyor and Municipal and County Engineer." The biographical

Mr. John A. Brodie, M. Inst. C. E., M. Inst. M. E.
(City Engineer of Liverpool and Surveyor to the Urban Sanitary Authority. President of the Incorporated Association of Municipal and County Engineers.)

sketch is based on one which appeared in the same journal.

Mr. Brodie has been city engineer of Liverpool since 1898, having been chosen to that position out of a large number of candidates from all parts of Great Britain. This, we hardly need state, is in striking contrast to the American way of filling a municipal office. As city engineer of Liverpool Mr. Brodie has charge of roads, sewers and the "cleansing department" (street cleaning, ashes and garbage collection and disposal, etc.). Under him are from 3,000 to 4,000 officials and laborers.

The professional career of Mr. Brodie began in 1875, in the engineering department of the Mersey Dock estate. In 1879 he gained a Whitworth scholarship and entered Sir Joseph Whitworth's tool works. Subsequently he was in charge of harbor works in Spain and then was general engineering assistant to the city engineer of Liverpool. In 1882 he entered into partnership with Mr. John T. Wood, M. Inst. C. E., subsequently engaging in water supply, sewerage, road, tramway and other engineering improvements. During this time he designed an apparatus for charging refuse destructors without storing the refuse on their tops, and also a combined destructor and steam generator.

As city engineer of Liverpool Mr. Brodie has carried out extensive street and sewer improvements, reorganized the cleansing department, and, in conjunction with the city electrical engineer, constructed more than a hundred miles of electric street railway. To provide a low cost street surface for residential districts Mr. Brodie has used blocks of "concrete macadam," and also "pitch macadam pavements." To utilize the clinker from refuse destructors and to help solve the "housing problem," Mr. Brodie has designed and built clinker-concrete laborers' dwellings, located in Eldon St., Liverpool. Of these "The Surveyor" says: "In his system the sides of a room, including the floors and ceilings, are put together at the joints by dovetails on a principle somewhat similar to that of a Joiner's box."

Since 1893 Mr. Brodie has been one of the honorary professors of engineering at Liverpool University. He was one of the first members and vice-presidents of the Liverpool Self-Propelled Traffic Association.

A brief extract from Mr. Brodie's inaugural address may be introduced, in conclusion, as giving (1) an idea of the character of the examinations held by the association of which he is president, and (2) some of his opinions on other phases of the work of the association, and particularly on the unwisdom and unfairness of characterizing attendance at association meetings as "outing" (or, as we should say in America, "junketing") trips. On these points Mr. Brodie said:

> The Association has also been looking after the interests of public bodies and the status of the municipal engineer by instituting qualifying examinations for young municipal engineers, the papers for which are prepared by a body of properly qualified professional men holding responsible and principal engineering positions, the subjects included in these examinations embracing:
>
> Water engineering,
> Engineering,
> Surveying,
> Building construction,
> Sanitary science,
> Public health law,
>
> and after completion of the written examination the candidates are examined orally in the different subjects, passing in turn before each of the examiners. Members of local authorities may be assured that the holder of the Association's diploma has had at least a competent engineering education and practical experience in engineering work, and is, from a professional point of view, qualified to take up the responsible duties of an engineer to a local authority.
>
> To the members of the Association this is of course very well known, but I have thought it well to make clear what the position and objects of the Association are, more especially as to-day the Association has taken a further step in its progressive policy by inviting representatives of various authorities to join and take part in our annual meeting, and it is hoped that this interchange of views on mutual ground between representatives of local authorities and their engineers will tend to broaden and enlarge the views taken of the bearing municipal engineering works have upon the health, comfort, and convenience of the inhabitants of our various districts.
>
> Of course, this method of education has a great many critics. It is said that such meetings and conferences with people interested in kindred subjects are practically "outings" at the expense of the public. It appears to be thought by some that statements to this effect are a sure method of securing notoriety, whilst others, with no doubt good enough motives, consistently object to any expenditure out of the public funds on visits or inspections of any description. Such criticism very rarely comes from the really thoughtful section of the community, and practically never from those who are really responsible for the carrying out of important works and improvements.
>
> Those statements do a great deal of harm, as they tend to prevent the best qualified and busiest men from giving their time to public duties, and they appear to many of us who are behind the scenes particularly ungracious when applied to the chairmen and members of committees who regularly give up a large amount of their valuable time and shoulder heavy responsibilities and fight them through, often in the face of considerable opposition. Chairmen of committees, in my opinion, seldom receive a tithe of the credit due to them for their often laborious and responsible work on behalf of the public.
>
> In my opinion visits to other towns, and where necessary to foreign countries, form an important part of the

education of any gentleman responsible for the execution of public works, and I believe great good would arise from a systematic examination by deputations of municipal works carried out in other towns and countries.

I have considered this policy of so much importance that since my election to the position I now hold it has been my consistent practice to visit during my summer vacation one or more of the great towns abroad in order to gather anything which might be of advantage in connection with carrying out the public works of this city.

A REINFORCED-CONCRETE SIPHON ON AN IRRIGATION CANAL IN SPAIN.

In the northeastern part of Spain in the provinces of de Huesca and de Lerida, there is a dry, arid country, the proper irrigation of which has been the subject of study since the 18th century. In 1896 these studies were brought to a head in the construction of an irrigation canal which collected the waters of the Rivers Essera, Cinca and Segre and distributed them through smaller ditches over the surrounding country. The project serves over 260,000 acres of land and cost approximately $6,500,000. The main canal is 74.4 miles long, the secondary, 37.2 miles and the distributing ditches total 102.3 miles. All the bridges, aqueducts and other works along the canals are built of reinforced concrete, and as a rule present no special novelty in design and construction.

One of the constructions which merits notice, however, is the reinforced concrete siphon which carries the main canal across the valleys of the Sosa and the Ribabona. Up to this time the largest work of this sort was the reinforced concrete siphon at Champ (Department of Isere, France), which was 10.5 ft. in diameter and calculated to take all pressure up to 57 ft. head. For pressures above that head, metallic pipe was used. The total length of the siphon in Spain across the Sosa and Ribabona is about 3,200 ft. and the maximum head 85 ft., with a flow of 1,240 cu. ft. per sec. through two tubes each 12.5 ft. inside diameter. It will be noted from the plan and profile shown in Fig. 1, that there are two rises and falls and that the pipe is carried over the two rivers on aqueducts.

Each of the tubes as constructed consists of a cylindrical sheet of ⅛-in. iron plate with an inside cement-mortar lining ⅞-in. thick, and an outside 6-in. thickness of concrete, reinforced with T-bars wound around the sheet-iron cylinder. The metallic cylinder was inserted to make the tube as strong as possible and in order to increase its efficiency, it was decided to join the ends of adjoining sections, each 21 ft. long, by an autogenic weld or solder. However, when the work was started it was found that this method necessitated a rather large plant for the decomposition of hydrogen and oxygen from the river water for use in the welding and that extra cost of plant and loss of time in making the weld were not justified by the results. Accordingly, riveted joints, as hereafter described, were substituted.

METHOD OF CONSTRUCTION.

The construction was carried out by first building a concrete cradle in which the iron tubes were set. Around these tubes the 6-in. concrete coating was then placed and finally the inside ⅞-in. cement mortar lining.

The concrete cradles (Fig. 3) were built in open cut in lengths of 20 ft., with intervals of 18 in. to allow for a working space in the placing of the iron tubes. Their inside diameter is just the same as the outside diameter of the finished siphon and their top comes to the horizontal diameter of the circular pipe. The steel tubes, that form the basis for the reinforcement of the pipe, are built in sections 21.3 ft long out of ⅛-in. plate. Each section is composed of 5 cylinders, each made up of 4 plates to the circumference. The extra reinforcement consists of a series of simple T-bars, wrapped around the steel tubing as elements of the circumference, not as spirals, and varying in size according to the pressure. The siphon was divided into four zones, corresponding to the pressures of 33 ft., 49 ft., 66 ft., and above 66 ft., with a corresponding size and number of bars for each zone. The tubes under the greatest pressure carried 52 T-bars, 1⅞ × 1⅞ × ¼-in. in size, distributed uniformly along the length of 21.3 ft. The reinforcement was completed by 80 iron ⅜-in. rounds, placed all along the outside of the tube, parallel to its axis, and buried at intersections to the circumferential bars.

After each length of tubing was covered with the reinforcing bars, it was rolled into place on some temporary tracks laid in the basin of the cradle and finally set, by use of the traveler shown in Fig. 5, on blocking which held it the proper distance above the cradle. In placing, the adjoining tubes were set with ends just 2 ins. apart, the intervening joint being closed as hereinafter described. It was found that the tubes would not keep their circular section and in order to have the circle perfect when set, the mandrels shown in Fig. 9 were devised. These mandrels, the construction of which can be readily seen from the drawing, were 6 in. thick, so that when placed at the joint of two tubes, there would be 2 in. in each tube. By means of the wedges shown, then, each tube could be forced into a perfect circle at the same time the two were made concentric.

The outside concrete was placed first. For this purpose no forms had to be built in the lower half of the circular section, the cradle acting instead. Battens, however, had to be built to keep the concrete from flowing into the joint excavations. After the lower half had been constructed, forms were built for the upper half, with a small opening at the top, through which the concrete was poured. All concrete was mixed by hand in a mixture approximately 1:1½:3. The mixing was carried on upon the upper bank outside the siphon and as the mix was very wet it could be placed by pouring into a gutter which ran to the forms (Fig. 6). All the while the concrete was being placed two men were stationed inside the pipe whose duty it was to keep continually hammering the tubing in order that the vibration so imparted would help the concrete to settle into a more compact mass.

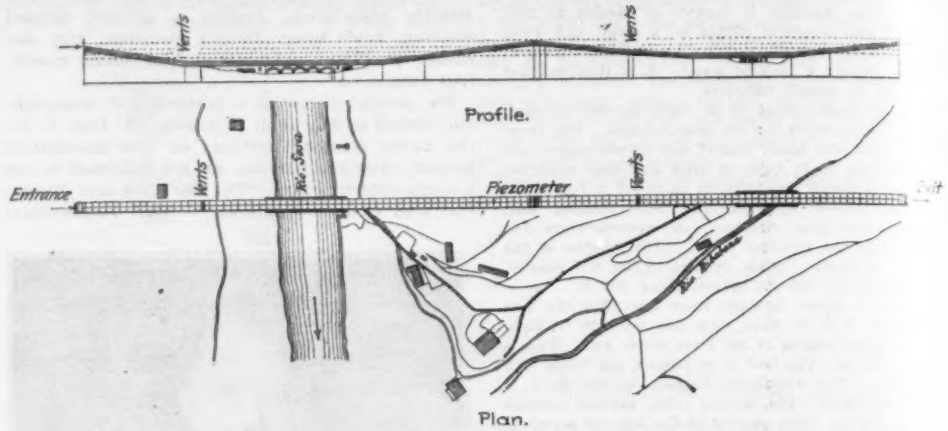

FIG. 1. PROFILE AND PLAN OF REINFORCED CONCRETE SIPHON ON IRRIGATION CANAL IN SPAIN.

EXPANSION JOINTS.—An interesting detail of the work is found in the joints to provide for expansion at the end of each tube section. As stated in the beginning of this article it was found impracticable to weld together these sheet-iron tubes, so instead, at each joint, where a space of 2 ins. was left, an iron circumferential ring with a semi-circular section made a riveted connection between the two tubes (Fig 7). On top of this tube was placed, in several layers, an elastic mixture consisting of from 80 to 85% coal tar and 20 to 15% asphalt. Then a ring of concrete was placed around the asphalt and tar and reinforced, in the same manner as the main outside shell, with circular T-bars and longitudinal iron rounds. The semi-circular connecting rings are supposed to be able to give and take with any movement in the pipe due to expansion or contraction.

LINING.—After the entire outside covering had been made and the structure subjected to all of the stresses due to erection, the ⅞-in. cement

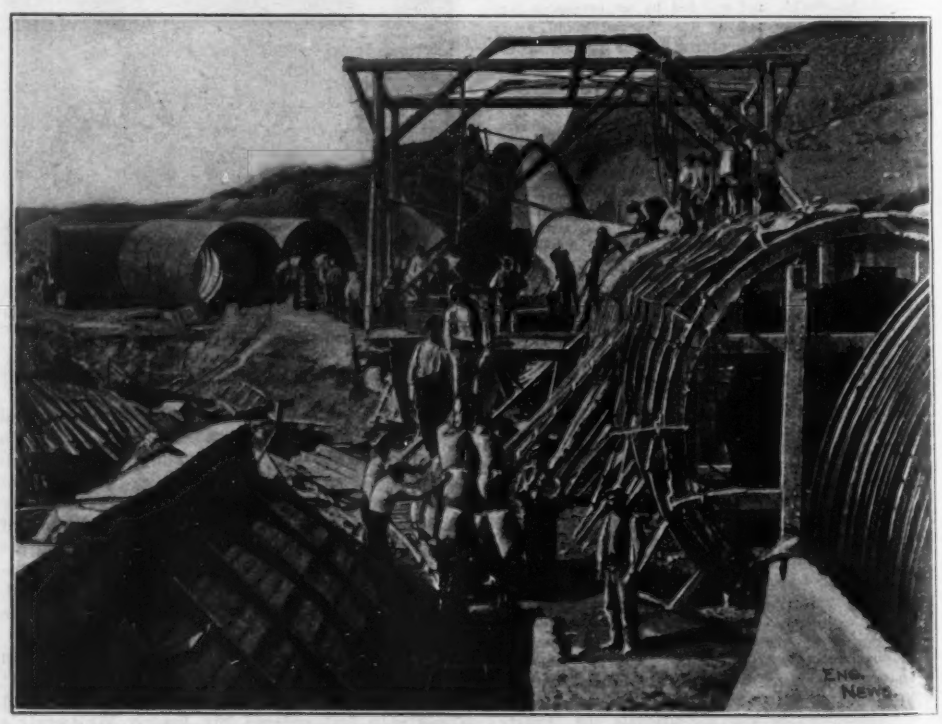

FIG. 2. CONSTRUCTION OF A SIPHON IN REINFORCED CONCRETE ACROSS THE RIVER SOSA IN SPAIN.

mortar lining was put on. The lining consisted of a 1:2½ cement mortar reinforced with a ⅛-in. wire-mesh which was used to ensure adherence to the iron tube. The forms for this work were built in short sections in the general shape shown in Fig. 3.

The siphon is provided with piezometer and vent-holes, at points indicated on Fig. 1. The

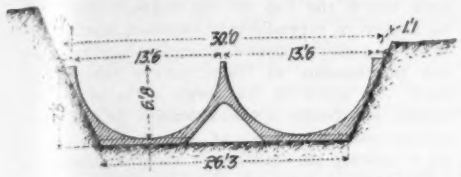

Fig. 3. Section of Concrete Cradles for Siphon.

whole work is now completed and in excellent working order. Some small leakage was at first noticed, but it has now ceased and the whole pipe is perfectly tight.

The engineers on the work were M. Aimé Bonna, consulting engineer, and Senor Mariano Luina, engineer-in-charge. The contractor was Senor Eugenio Ribera. For the information and illustrations herewith presented we are indebted to

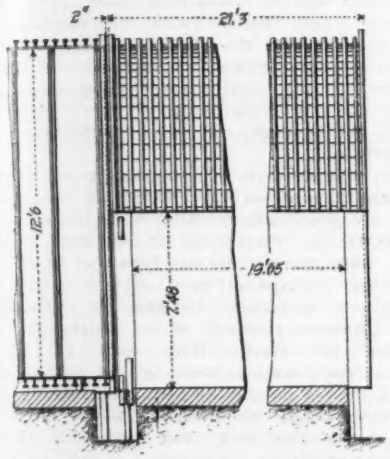

Fig. 4. Elevation of Steel Reinforcing Tubes and T-Bars for Reinforced Concrete Siphons.

Le Genie Civil, in an article by M. Henri Martin, who in turn acknowledged his debt to an article by Senor Luina in the Revista de Obras Publicas.

UNITED STATES IMPORTS for the year ending June 30, 1907, were valued at $1,434,000,000, which was an increase of more than $200,000,000 over the year preceding, and was more than double the corresponding figure

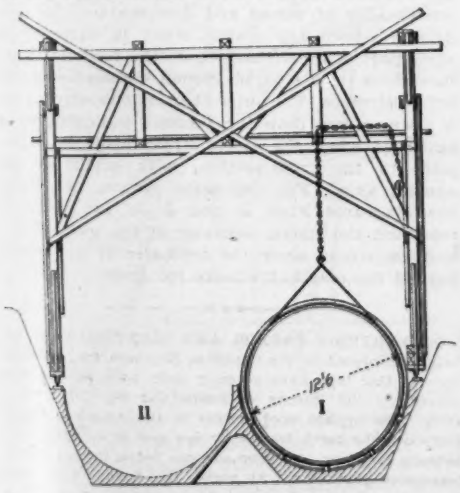

Fig. 5. Method of Setting Steel Tubes in Reinforced Concrete Siphon in Spain.

for the year 1899. Exports for the year ending June 30, 1907, amounted to $1,881,000,000, which was an increase of $137,000,000 over the previous year, and of 53% over the year 1899. A very large proportion of the increase in exports for 1906-07, as compared with 1898-99, consisted of crude materials for manufacturing purposes and of food-stuffs in a crude condition.

WATERPROOFING COAST DEFENSE STRUCTURES.

There is no series of works upon which the details of waterproofing must be studied to a greater extent than in the various chambers and compartments of the coast defense stations. The U. S. Corps of Engineers have been experimenting upon the different methods of waterproofing such stations at all of the many coast-defense batteries on both oceans, and the reports of such tests are annually incorporated in the reports of the Chief of Engineers where, unfortunately, they are buried from the sight of most engineers in civil practice. The following abstract gives the major portion of some advance notes of two

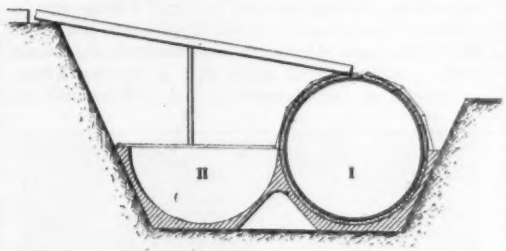

Fig. 6. Method of Pouring Concrete for Outside Covering of Siphon Across River Sosa, in Spain.

of these reports which have recently been published.

COAST OF MAINE AND NEW HAMPSHIRE.—The entire surface of a concrete chamber is covered with a ¾-in. coat of hydrolene which is carried over the entire surface of the undercuts, being there bonded to the concrete by coal tar. On the hydrolene is placed either one layer of tar paper or two layers of hydrex felt. On this is placed hollow tile, bonded to the waterproofing with hydrolene, and with the hollows in line with the slope, but a gutter 6 ins. wide is left along the traverse and parapet walls. Concrete paving is placed over the tiling and the gutter is covered with an angle iron bolted in place. The cost of the work in the one platform completed is $12.64 per sq. yd.

The object of the tiling is to drain the waterproof layer. The gutter is to permit free expansion and contraction of the pavement, and to render the waterproofing accessible along the line of the vertical walls, where failure is most to be expected.

The above treatment made over two years ago has proved very efficient. Some few changes, however, will be made in future work. When soft burned porous tile are kept saturated with water and exposed to alternate freezing and thawing under the severe conditions of the Maine climate, they are broken up. In the latest work, tile laid in positions subject to such exposure have been boiled in paraffin before placing. Each tile thus treated took up about ½-lb. of paraffin, and subsequent tests showed that the treated tiles had become non-absorbent.

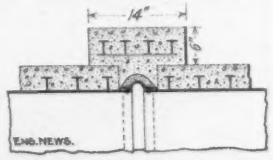

Fig. 7. Expansion Joint in Reinforced Concrete Siphon.

In one of the older batteries the galleries in the traverse were very wet. A coat of Staso cement applied on the surface, in conjunction with the Staso compound in the larger cracks, which were widened to receive it, made a decided improvement. The amount of surface covered was insufficient to stop all leaks, and further work remains to be done.

In another battery, where expansion cracks had formed in the landing platform and caused leaks in the galleries beneath, half-inch expansion joints were formed 10 ft. apart and filled with the elastic Staso compound, and the smaller intermediate cracks were filled with the nonelastic glycerine and litharge cement. This was also fairly successful. This cement bonds strongly with the concrete. Coal tar pitch applied with a brush while melted was also tried successfully on the top of the traverses, in the same manner as in the New York district.

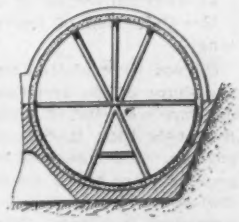

Fig. 8. Interior Forming for Reinforced Concrete Siphon.

Another leaking traverse was treated on its top surface with paraffin after the larger cracks had been filled with Webster's cement. A mixture of 1 part white paraffin wax and 2 parts kerosene heated to a temperature of 212° F. was applied to the surface with a brush. The mixture cooled at once and left a thin skin on the surface of the concrete. This was then gone over with a hot smoothing iron, such as is used for asphalt pavements, and the paraffin largely disappeared into the concrete. Eighty-eight pounds of paraffin were used on 2,400 sq. ft. of surface at a cost of $0.014 per sq. ft. The work resulted in a great reduction of the leakage into the traverse rooms. Another application of the paraffin being made now seems to show that the coat applied last fall has penetrated the concrete sufficiently to permit the absorption of more paraffin. The application of the paraffin darkens the color to that of wet concrete.

Elaterite cement paint, manufactured by the Elaterite Paint & Manufacturing Co., of Des Moines, Iowa, has been given a short test on the surface of a leaky gutter sunk in the top of a traverse. It spreads thinly on the concrete, adheres strongly to it and renders it waterproof. Should it stand the test of time it is a very valuable waterproofing material. Its color is black.

A mixture by volume of 3 parts litharge, 1 part glycerine, 48 parts Portland cement and 48 parts sand, makes a strongly adherent and dense plaster, which has been used with some success in the ceiling of a leaky traverse room, through which water had been percolating freely. A groove cut in the ceiling in the side from which the greater part of the water apparently came afforded a drain, and the plaster coat prevented the general percolation through the ceiling. The plaster bonded well with the concrete without other aid than cleaning the surface with a wire brush. It has been in too short a time to be tested thoroughly.

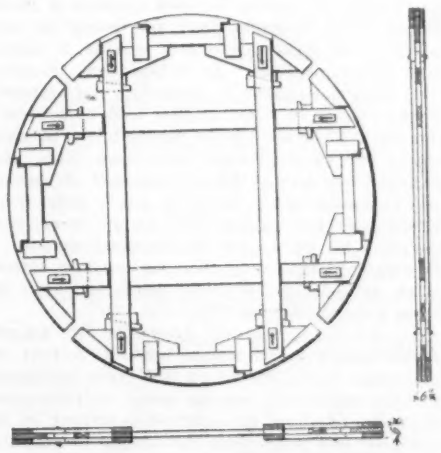

Fig. 9. Mandrel Used in Shaping Steel Tube in Reinforced Concrete Siphon.

EASTERN ENTRANCE TO LONG ISLAND SOUND.—The coating of Elliot's Roof Leak on concrete superior slopes, which appeared to be excellent for several months, began to scale under wear after a year. A new sample of Hydrolene B, melting point 200° F., and Staso liquid cement, applied over two years ago, on cold surfaces, wear well to the present time; the sanded better than the unsanded parts. Each penetrates and adheres to the concrete. Staso has an Indian red color fading on exposure; Hydrolene B has a fast black color. Nicolite Nos. 1 and 2, and Szerelmey did not appear so suitable. Linseed oil waterproofing has been extensively used in this district and regarded favorably. Staso Compound No. 5 was placed in a vertical joint one inch wide and two inches deep some two years ago. It showed a tendency to run in warm weather and bulge out of the joint; it is pliable and easily worked back. When examined some six months later the surface of the compound was full of fine cracks, but the material adhered strongly to the concrete. Webster's elastic cement was continued to be used extensively in wide vertical and horizontal joints and cracks with good results.

Linings made at new batteries at Fort Michie are of porous brick, porous tile, and porous mortar. Careful observations here as to condensation were made at frequent times since early April, 1905. The report records a very general absence of condensation at the linings except at non-porous mortar joints; that condensation on concrete or metal surfaces quickly disappeared when rooms were opened at times of clear and dry weather, and even that such moisture was noticed in one case to disappear over night of good weather, although the battery was tightly closed. In summing up conclusions the different linings used in order of effectiveness are:

Hollow porous tile.
Porous brick (Infusorial Earth Company).
Porous mortar, ½-in. coat.
Rough-finished concrete.
Smooth-finished concrete.

TEST OF A CAST STEEL BEAM.

By J. V. McADAM,* M. E.

In designing cast steel beams, as for example car bolsters and truck side-frames, it has been the practice to locate the neutral axis of the section nearer the tension side than the compression side, by making the tension flange the larger, so that the stress in tension is less than that in compression. One reason for this practice is that any defects, such as blow-holes, shrinkage cracks, internal stresses, checks or seams, are less serious in the compression side, and the designer can therefore afford to risk more than in the tension side. Defects in the tensile fibers act not only to reduce the strength but cause a concentration of the stress at the defective point. How much excess of tension area should be allowed on this account depends upon the use to which the casting is to be put, upon the seriousness of results of a failure, and also upon the liability of any or all of these defects being present. Car bolsters, for example, are usually given an excess of 20 to 30% in the tension flange. Yet it is the writer's observation that out of say 1,000 car bolster failures, 999 occur on the tension side of the casting.

Probably because of this enormously greater prevalence of tension failures there is a feeling among steel founders that the metal in commercial soft steel castings is weaker in tension than in compression. It is true that numerous tests have been made to determine the properties of the metal in both tension and compression, and these have shown the strengths to be about equal; but all such tests have been made upon standard test bars. While thousands of castings have been tested to see how much they would deflect, and how much they would carry, little seems to be known as to the exact amount of the strain in the outer fibers on top and bottom, in an actual casting under load, although the stress is easily figured.

In order to, if possible, determine the amount of this strain in an actual casting, and at the same time get a record of the exact movement of every point in a casting under varying loads, the writer devised the method described in the following, and selected as the casting to be tested one with the simplest possible cross-section, namely a rectangle.

A 2-in. slab, 30 ins. long and 7 ins. wide, was cast, and out of it was cut a bar 5 × 1 1/32-in. and 30 ins. long. The bar was not annealed. Its chemical analysis was as follows:

C 0.24%; S 0.018%; P 0.028%; Si 0.22%; Mn 0.68%.

This bar was laid flat on a planer bed, and with a round-nose tool grooves were cut crosswise 10 to the inch, and to a sufficient depth to leave the bar exactly 1 in. thick at the root of the grooves. This produced on one side of the bar a series of sharp tranverse ridges about 1/64-in. high, and these ridges were in turn nicked across by cutting 10 grooves to the inch lengthwise of the bar with a tool about 1/20-in. wide.

By laying a long sheet of paper upon the grooved surface of the bar with a sheet of carbon paper between, a sharp carbon impression of every little ridge was obtained on the long sheet of paper by the use of a rubber roller. This gave the exact original location of every point in the side of the bar. In order to be able to identify any point, five of the short ridges at the center of the bar were cut away, leaving one more prominently exposed, which could be easily located on all carbon impressions and used as a base from which to make measurements.

The bar was placed on edge in a 100,000-lb. testing machine, on two supports 28⅞ ins. apart, and loaded symmetrically at two points 12 ins. apart. This gave uniform bending moment in all sections in the central portion of 12 ins., so that the bar bent into the arc of a circle. Also, with this arrangement of loads and supports the stress in the outer fibers was the same as the total load on the machine, thus obviating the necessity of calculations. The bearings for supports and loads were 1-in. round tool steel.

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Carbon impressions were made for every increment of 5,000 lbs. up to 40,000 lbs. total load, then for every 2,000 lbs. up to 70,000 (corresponding to an extreme fiber stress of 70,000 lbs. per sq. in.). The load was released after each increase and an impression taken to determine the permanent set. After reaching 70,000 lbs., impressions were made for every 10,000 lbs. down to zero load and back. Then the load was increased 2,000 lbs. at a time up to 100,000 lbs., the limit of the machine, a no-load impression being taken after each increase as before. From 100,000 the load was diminished in steps of 10,000 lbs. back to zero.

Altogether 98 impressions were taken. Their appearance is represented by Fig. 1 herewith, a reproduction of part of the impression made at 90,000 lbs. load. All sheets were carefully measured with a flexible steel scale and a reading glass, to determine the elongation and compression in

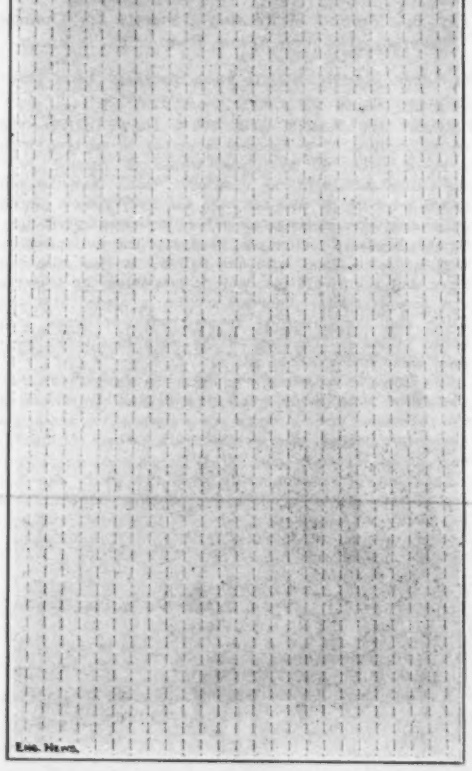

Fig. 1. Part of Carbon-Paper Impression of Grooved Face of Beam Under Load of 90,000 Lbs.

the outer fibers, and the deflection of the neutral axis.

All measurements were made upon the central 10 ins. of the bar, and five sets of figures were obtained, showing:

A.—Elongation in tension side under load.
B.—Compression in compression side under load.
C.—Permanent set in tension.
D.—Permanent set in compression.
E.—Deflection of neutral axis in central 10-in. length.

Curves were plotted on separate sheets so that the shape of the first one would not influence the draftsmen's mind in drawing the second, and the five were then traced on to one sheet for comparison. All measurements were made with the greatest care and a smooth curve drawn through the points thus located. In no case did any observation lie more than 1/500-in. (deformation) away from the curve, showing that as a whole the measurements were very accurate. This is apparent from Figs. 2 and 3, showing the measured values of elastic and permanent compression and elongation and the curves drawn to represent the results.

During the test there was a slight thickening of the compression edge and narrowing of the tension edge, although the calculated stress in the extreme fiber reached more than twice the elastic limit. The points where load was applied crushed down perceptibly at the higher loads, and the impressions showed that the influence of the vertical compression extended about an inch below the top of the beam. [This cannot be shown in reproduction because just under the loads the metal spread laterally enough to make the impressions at these points rather light.—Ed.] In spite of its large ratio of height to width, the beam did not buckle perceptibly out of the vertical plane, at any rate not so much as to modify the calculated stresses materially.

Comparison between the compression and tension values is facilitated by Fig. 4, where the curves of Figs. 2 and 3, together with the deflection curve, are superimposed. It will be noted that up to the elastic limit the steel is stiffer in tension than in compression, and that for some distance beyond this point the compression is the stiffer; when the curves again come together and as the breaking point is approached there seems to be little difference between the value in tension and compression.

It will also be noted that from curve "A" it would appear that the elastic limit in tension was at about 40,000 lbs., while the permanent set measurements showed no set up to 47,000 lbs. From "C" it would seem that permanent set took place in compression at about 50,000 lbs., while the set-curve "D" shows permanent set at 47,000 lbs.

The diagrams are in every way typical and the release lines down from 70,000 lbs. and 100,000 lbs. are practically parallel with the curves up to 40,000 lbs. Permanent set took place at 47,000 lbs., while the bar did not break at 100,000 lbs., and the indications were that it would have gone to at least 110,000 lbs. Ordinarily the ultimate strength of a casting is about double the elastic limit, and all of the above would seem to indicate that giving a casting a limited number of permanent sets does not seriously impair its strength, but simply raises the elastic limit to a value nearer the ultimate strength.

Tension test bars cut from thoroughly annealed samples of this same chemical analysis showed an elongation as high as 15%, with a reduction in the ultimate strength to 85,000 lbs. If this figure could be compared directly with the apparent ultimate strength shown by the bending test, the conclusion might be drawn that for some purposes unannealed steel is better.

But the fiber stress calculated from a bending test employs a formula which presupposes proportionality of stress and deformation; for conditions where the elastic limit is exceeded in some part of the cross-section, the formula therefore gives results which cannot correspond to the actual stresses. The outer fiber undoubtedly carries a lower stress than the formula indicates, as is apparent when the stress-strain diagram is applied to the cross-section, with origin at the neutral axis. For the same reason, of course, the diagrams Figs. 2 and 3 do not correctly represent the elastic behavior of the metal under uniform stress, since the ordinates of unit-stress beyond the elastic limit are too great.

CONVERTIBLE PARLOR AND SLEEPING CARS are being introduced on the Canadian Northern Ry., and some cars of this type have recently been built for the road named by the Barney & Smith Car Co., of Dayton, Ohio. The system used is that of the American Palace Car Co. The berth frames by day rest in compartments beneath the floor, the floor sections being formed by the transverse partitions. At night, the frames are raised by steel cords wound upon a drum, and are supported in place by fixed posts. The chairs and hand baggage are then stowed in the compartments. There is greater head room than in ordinary sleeping cars, and the berths are wider in consequence of the absence of the end supports of fixed seats. The cars for the Canadian Northern Ry. are 72 ft. 6 ins. long over the end sills, and 9 ft. 10½ ins. wide over the side sills. They have kitchen and buffet equipment and an observation room and platform at one end.

THE NEW OFFICE AND FACTORY BUILDINGS OF THE KEUFFEL & ESSER CO., HOBOKEN, N. J.

On Saturday, July 20, the Keuffel & Esser Co., well-known manufacturers and importers of engineering and mathematical instruments, formally opened their new reinforced concrete office and factory building at Adams and Third Sts., Hoboken, N. J. The new buildings practically double the facilities of the company. The former general offices of the company, at 127 Fulton St., New York City, are now removed to the more commodious quarters in Hoboken, and the Fulton St. building is retained simply for the New York sales department.

The new buildings, two in number, are directly across Adams St. from the old factory buildings. The office building is five stories in height, and the factory building six; a two-story structure connects the two. They are practically alike in construction, the office building being slightly more elaborate in finish.

The two buildings together cover about 30,000 sq. ft. of ground. The office building is U-shaped, with a 200-ft. frontage on Adams St. and wings of 100 ft. frontage at each end, with a width of 50 ft. The factory building is 225 ft. × 60 ft.

In the office building the first floor is entirely devoted to the shipping and receiving departments. The general offices cover the second floor, and the other three floors are devoted to stock-rooms and storage.

The first four floors of the factory building are used for wood-working. Facilities for lumber-storage are provided by dividing off the rear of the first two floors by a fire-wall. The fifth floor is given up to paper-mounting, and the sixth is entirely devoted to manufacture and calibration of measuring tapes.

The wood-working machinery in the building is driven by individual motors, carried by metal supports firmly bolted to the floor or ceiling. An exhaust system for removing shavings and saw-dust has been installed. The fans, direct-driven, force the dust and shavings through pipes to the outside of the building, where they enter a separating drum; from this drum they are drawn, from the bottom, through two 16-in. pipes beneath Adams St., to a drum on the roof of the boiler house; from there they are automatically fed to the fires beneath the boilers.

The boiler capacity of 1,000-HP. is used for developing electric power, which drives all machinery and lights the buildings. Exhaust steam, with a vacuum system of boiler return, is used for heating.

Throughout both buildings the Esty system of automatic sprinklers, made by the H. G. Vogel Co., is installed; the sprinklers run in six parallel lines, through each floor. There are two stairways and two elevators in each building, shut off from the floors by concrete partitions and iron doors, held open, when necessary, by fusible links. All windows are of wire-glass, with metal sashes; when open, fusible links in the fastening chains will allow them to swing shut in case of fire. Two tanks of 50,000 gals. each, on the roof of the factory building, hold a reserve of water for the sprinklers.

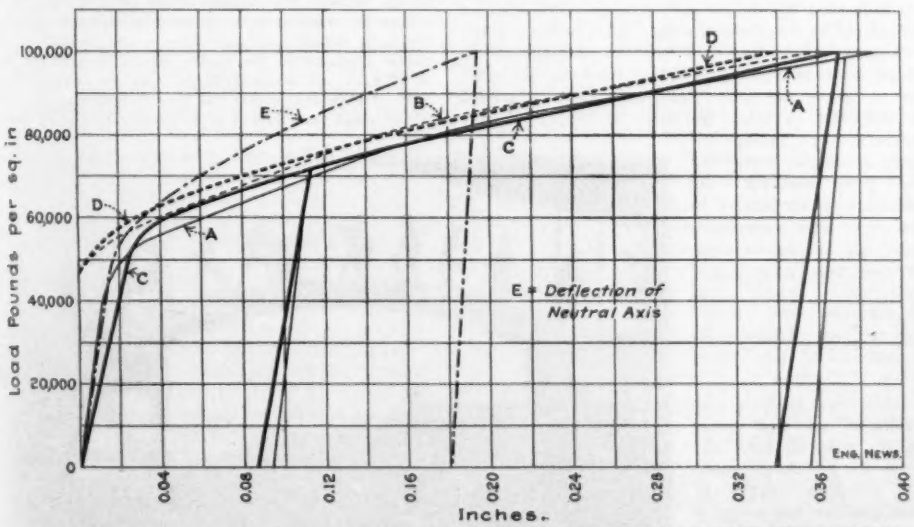

FIG. 2. DIAGRAM OF ELASTIC AND PERMANENT COMPRESSION.

Beam 5 × 1 × 30 ins., tested on edge. Two symmetrical loads 12 ins. apart. Ordinates are sum of loads. Measurements made on central 10-in. length.

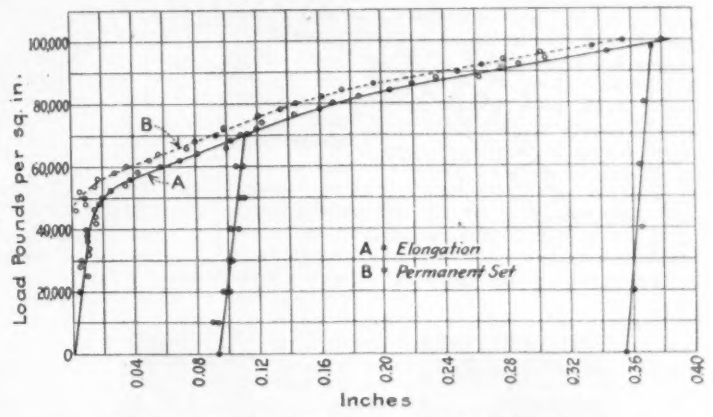

FIG. 3. ELASTIC AND PERMANENT ELONGATION.

FIGS. 2 AND 3. STRESS-STRAIN DIAGRAMS OF TENSION AND COMPRESSION SIDES OF CAST-STEEL BEAM.

FIG. 4. CURVES OF TENSION, COMPRESSION AND DEFLECTION OF CAST-STEEL BEAM.

All measurements on central 10-in. length.

L. M. Meystre & Son, architects, of Hoboken, N. J., designed the buildings; the Turner Construction Co., of 11 Broadway, New York City, built them.

At the opening ceremonies on July 20, Mr. W. L. E. Keuffel, Secretary, addressed the guests on the construction of the buildings; this address was followed by one from Mr. W. G. Keuffel, Vice-President, after which Mr. C. M. Bernegau, Treasurer, gave an outline of the history of the company, from its birth in 1867, in a single room on the third floor at 79 Nassau St., New York, to the present. After the ceremonies were completed the guests were escorted through the buildings on a tour of inspection, ending in a buffet luncheon on the fifth floor of the office building.

TYPHOID FEVER AT WASHINGTON, D. C., DURING THE FIRST HALF OF 1907.

Typhoid fever at Washington having attracted so much attention throughout the country since the new water filtration plant was put in operation, the leading typhoid statistics for the District of Columbia for the first six months of the present year will be of interest to many of our readers. These figures have been kindly supplied to us, at our request, by Dr. William C. Woodward, Health Officer of the District of Columbia. They are shown herewith as Table I.

TABLE I.—CASES AND DEATHS OF TYPHOID FEVER IN THE DISTRICT OF COLUMBIA, JANUARY-JUNE, 1907.

	Cases			Deaths		
Month.	White.	Colored.	Total.	White.	Colored.	Total.
January	46	7	53	6	1	7
February	28	4	32	3	3	6
March	23	2	25	2	2	4
April	20	8	28	3	3	6
May	30	8	38	4	3	7
June	30	6	36	1	1	2
Total	177	35	212	19	13	32

For purposes of comparison with earlier years, we give in Table II. the number of deaths from typhoid fever in the District of Columbia by months for the first half of 1906 and for each of the five years 1901-5, together with the average for the five-year period. The filtration plant was put in partial operation in August, 1905, and since the October following nothing but filtered water, we understand, has been supplied to the city. It will be seen that the total number of deaths for the first six months of 1907 was 32, as compared with 38 for the same period the previous year. In 1905, or just before the filtration plant was put in service, there were but 28 deaths from typhoid fever during the first half of the year. The average, however, for the five years 1901-5 gives 42 deaths.

We do not present these two tables as evidence for or against the efficiency of the filter plant, but merely as a matter of record, in view of the great interest now attached to the course of typhoid in Washington, and also in view of the recent appearance of the report on Washington typhoid just published by the U. S. Public Health and Marine-Hospital Service. (An abstract of this report and also some editorial comments on it were published in our issue of July 11.) It should be remembered that it is during the last six months of the year that typhoid fever mortality has been most notably high in Washington, and that relatively small typhoid fluctuations during brief periods of time have little significance.

TABLE II.—DEATHS FROM TYPHOID FEVER IN THE DISTRICT OF COLUMBIA BY MONTHS DURING THE FIRST HALF OF EACH YEAR, 1901-07.

	1906.	1907.	Av., 1901-5.	1905.	1904.	1903.	1902.	1901.
Jan.	6	7	10.2	11	5	9	19	7
Feb.	4	6	4.2	1	3	5	8	2
March	5	4	8.0	5	6	9	12	8
April	4	6	6.8	7	10	6	9	2
May	10	7	6.4	1	8	6	13	4
June	9	2	6.6	3	8	3	9	10
Total	38	32	42.2	28	42	38	70	33

REMOVING A STONE ARCH BRIDGE OVER THE NORTHERN RAILWAY OF FRANCE.

The Northern Railway of France decided some time ago to build four tracks on its line from Paris as far as Survilliers on account of the frequent interference of suburban trains with the through trains. The two-right-hand tracks will be for the through passenger and freight trains, which will run around the stations so as not to interfere with operation. The two left-hand tracks will be for local and surburban trains, and will serve the existing stations and platforms. At St. Denis (Paris) and Survilliers the junctions between the double-track and four-track lines will be so arranged as to avoid all crossings of the tracks at grade.

The work was commenced in 1905, and in addition to the earthworks for widening the roadbed and the station facilities, they include the replacement of highway crossings by bridges or subways, and the lengthening of a number of existing highway bridges and subways. The execution of the work was specially difficult at certain points due to the conditions of heavy traffic on the roads near Paris and on the railway itself. It was necessary to maintain the two original tracks in continual service and safety, the delay of trains being allowed only under exceptional circumstances. It was also necessary to maintain all roads open for traffic during the alterations. The difficulties were increased by the presence of street railway tracks, electric conduits, gas and water mains, sewers, etc., in the streets.

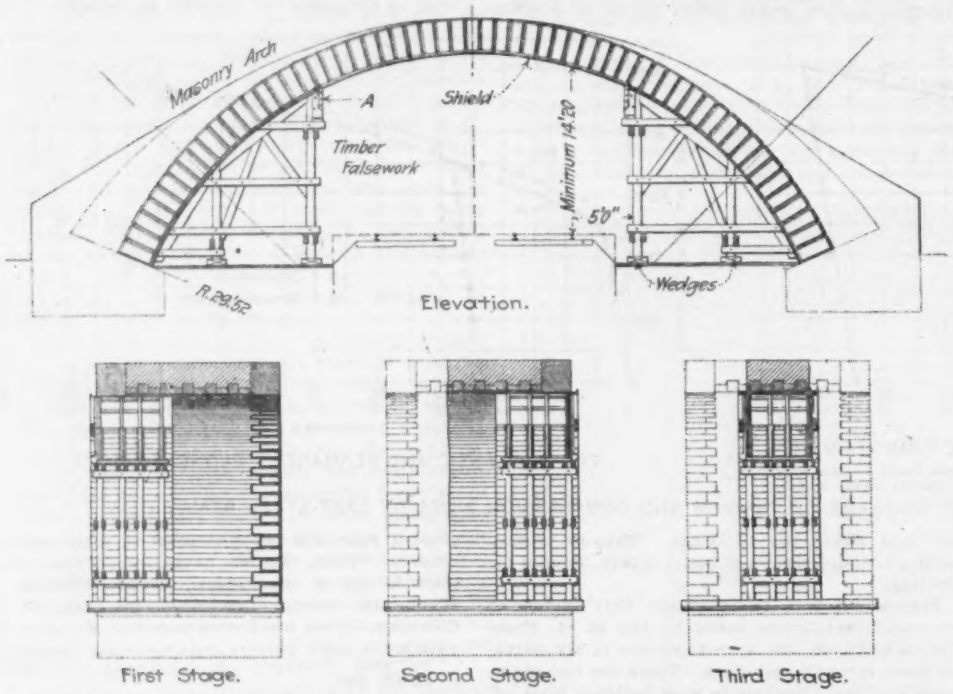

FIG. 1. REMOVING A STONE ARCH BRIDGE BY MEANS OF SIDE FALSEWORKS SUPPORTING A CENTRAL SHIELD; NORTHERN RY. OF FRANCE.

Work of a specially interesting character was the removal of masonry arch bridges spanning the tracks at a point where trains run at very high speed. Steel truss bridges were first erected, spanning the space for the four tracks, and the arches over the double-track line had then to be removed without interfering with traffic. This work is described by Mr. Rossignol, Chief Engineer of Maintenance, in the March number of the "Revue Generale des Chemins de Fer." The arch bridges had spans of 55.76 ft. at the springing (at the level of the roadbed), with a radius of 29.52 ft., and a width of 15.42 ft. It was not possible to support the arches on centering owing to the limited clearance: 0.26-ft. in one case and 0.26 to 0.85-ft. in the other. Two plans were therefore considered:

(1) To remove as much masonry as possible and then blow up the arch, taking such precautions that the debris would be of small volume and could be removed rapidly. (2) To take down the arch gradually, and in the demolition to adopt such methods that the load to be supported would be very light and that it would be sufficient to place beneath it merely a thin platform or shield instead of actual centering. The first method was successfully employed in one case, with assistance from an engineer regiment of the army, but it was very costly and necessitated the interruption of traffic for a period of three hours.

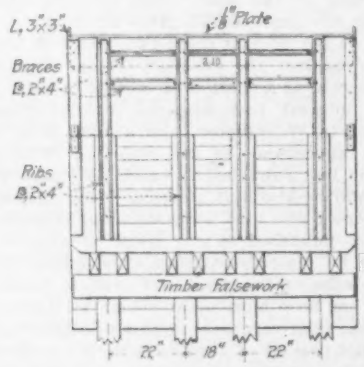

Fig. 2. Section Through Shield.

The second method was employed at the other bridge, and enabled the work to be done without stopping traffic or even limiting the speed of trains. The plan adopted was to build timber falseworks under each side of the arch, supporting a shield composed of four 4 × 2-in. channel-iron ribs spaced 22 ins., 18 ins., and 22 ins. apart, with cross braces of similar channels between them, and covered with ⅛-in. plates. The ribs were bent cold to the exact radius of the arch, and their ends were made vertical for attachment by spikes to the posts of the falseworks on either side, as shown at A in Fig. 1. This shield occupied a space only 2⅛ ins. deep, and left a clearance of 1 in. above the clearance limit for the rolling stock. The ribs were hoisted into place by ropes passed through holes drilled in the arch, and when these were secured to the posts, men mounted on double ladders slipped the plates in place, and bolted an angle iron ring along their ends at each side of the shield. The shield and falsework were then brought in contact with the arch by driving up the wedges at the feet of the posts.

The shield being only 7 ft. wide (the length of the plates employed), and the bridge being 15 ft. 6 ins. wide, the arch was removed in three sections. The two outer sections were first removed, and finally the middle section. To shift the shield and falsework, the wedges were slackened and the whole structure slid along on oak sills. As a rule the shield supported but little load, until the breaking of the last ring, but as much as possible of the masonry was removed before this. The small amount of masonry and the weight of the workmen produced little appreciable deflection of the shield. At one of the bridges, a section of the masonry separated as soon as the keystone was removed, and rested with all its weight on the shield, causing some deflection; the shield returned to its normal position as soon as this weight was removed.

During the progress of the work, watchmen with red flags and torpedoes were stationed 3,280 ft. from the bridge in both directions. Before each train was due, the work of removing the masonry was stopped and the condition was inspected, while the clearance height above the rails was also measured. The watchmen were then notified by signal that all was safe. As a matter of fact, no trains were stopped or even delayed. The work was done under the direction of Messrs. Paris and Perroud, Engineers of Maintenance of Way. Fig. 1 shows the general character of the work, and Fig. 2 is a section through the shield; Fig. 3 is a view showing the work in progress.

FIG. 3. REMOVAL OF A STONE ARCH BRIDGE OVER THE NORTHERN RY. OF FRANCE.

DEPOSITS OF STEEL-ALLOY METALS throughout the United States will be investigated by the Geological Survey, and a report giving the results will be published later. The investigation is to be made by Mr. F. L. Hess. He will visit South Dakota, Idaho, Colorado, Montana, Washington, Oregon, California, Nevada, Utah and Arizona. All of this summer and fall will be occupied by the work. The metals to be covered are: Nickel, chromium, manganese, tungsten, molybdenum, vanadium, titanium, cobalt, and uranium. The value of these metals produced in the United States in 1906 amounted to $458,327, of which $393,667 was for tungsten. The price of tungsten, which has been increasing for a number of years, was quoted at $5 to $6 per unit (1 per cent of a ton) in 1905, and at $12 per unit in the spring of 1907. Only small quantities are at present imported into the United States, as European markets utilize practically all that is produced in foreign localities, mostly in Peru and Australia. Large deposits of tungsten are found in Australia, and it is not improbable that sufficient may be obtained there to permit a certain portion of it to be shipped to the United States.

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Entered at the New York Post-Office as Second-Class Matter.

The lot of the public-service corporation official is indeed hard in these days of big clubs and sharp sticks. As an example, here is the Scranton "Scrantonian" accusing the president of the Scranton Gas & Water Co. of getting "profit both ways," by first "charging for drinking water that we are told [not by the water company.—Ed.] is unfit to drink, and, second, by charging for gas to make the water fit to drink." One can scarcely conceive of a corporation official with such an intention, but apparent indifference to the public interest on the part of franchise companies, in more than one American city, has begot just such opinions in the minds of large numbers of consumers as are expressed in the quotation. Fortunately, there is a change for the better on the part of corporation officials, but it will take a long time and much more than promises to reassure an indignant public, even where that public has been less badly wronged than it thinks.

Have paving engineers failed to achieve the ideal any more notably than have engineers or professional men of any class? This question has been prompted by the strong assertions of Mr. Geo. W. Tillson, M. Am. Soc. C. E., in opening a discussion on street pavements at the annual convention of the American Society of Civil Engineers, on July 10 (see article elsewhere in this issue). While we dislike to seem to disagree with so eminent an authority on paving as Mr. Tillson, we feel compelled to say that he seems to underrate the work of the best paving engineers of this and foreign countries when he says that they fall farther short of attaining perfection in their work than do architects and bridge engineers.

We agree with Mr. Tillson that "The perfect pavement has never been constructed." We go further, and say that it never will be seen by any engineers now living except they be fortunate enough to catch a glimpse of those pavements described by the Apostle John in Holy Writ; and even those pavements are nowadays subjected to the "Higher Criticism"!

The responsibility for the failure of pavements compared with other engineering works (if there be such failure) lies elsewhere than with the engineer. It may be found, largely, in the highly unsatisfactory governmental and political conditions which so generally control the construction and maintenance of pavements, and also in the numerous, varied and conflicting requirements for a good pavement.

It must be freely admitted that we have, in the United States, very few thoroughly competent paving engineers, compared with the amount of pavement laid every year, but this is because the nature of paving problems and the need for competent paving engineers is not yet recognized by the municipal public and the layman-official. Indirect evidence of this is borne in Mr. Tillson's own remarks about asphalt specifications, contractors and guarantees, in which remarks he quite definitely states that there are but few engineers in the country competent to design asphalt pavements suitable for different conditions.

Does any one doubt but what the number of such engineers would speedily increase until all possible needs were filled if only our cities were as ready to compensate paving engineers as adequately as they do the leading hydraulic and sanitary engineers when a difficult problem in water supply or sewerage demands solution?

Many other aspects of the question might be dwelt upon at length, but we can give only brief mention to two or three. The first and most important one is the hopelessness of ever attaining the ideal in pavements when, as a rule, the best and most expensive pavements the engineer puts down are not only shamefully neglected as to maintenance, but are ruthlessly broken into and then shiftlessly replaced by public-service corporations and often by the municipality itself. Again, why do none, or practically none, of our American cities use sand or gravel to prevent slipperiness on asphalt and on wood blocks during wet or icy weather? The practice is common enough abroad.

The American public goes to extremes. After years of apparent content with rough, dusty or muddy streets, it suddenly demands of the engineer not merely an ideal, but a multi-ideal pavement, with a number of the requirements diametrically opposed to each other: a glassy-smooth, but non-slippery pavement; no joints for the collection of dirt, yet a good foothold for horses; noiselessness, yet on iron-clad wearing surface.

The pavement once laid, neither money nor intelligence nor backbone is provided to keep it in repair, to clean it, to sand it when needed to prevent slipping, nor to restrain franchise companies, private individuals and city departments from riddling it with holes and trenches nor from littering it with all sorts of dirt.

We do not wonder that Mr. Tillson, after years of trying experiences with pavements in Greater New York, should turn pessimistic at times, but in so far as engineers and the possibilities of engineering are concerned, we think they are not the cause of the difficulties he sets forth.

CONCERNING WEALTH AND WAGE EARNERS.

A great many people are coming to believe that there is something wrong with Society as at present organized. The Socialist party represents the most radical element among those who protest against existing conditions, and Socialist candidates poll every year a steadily increasing number of votes in National, State and local elections.

Even more notable than the increase in the number of avowed Socialists is the rapid spread of socialistic ideas. The public, or a large proportion of it, is being steadily educated by a certain section of the daily press, and by literature in other periodicals and in books to a belief that these current protests against wealth—against the right to hold property, against the wage system and so on—have a sound basis.

This spread of socialistic ideas is not confined by any means to the so-called working classes. One finds men of property and of education, professional men, business men, teachers, lawyers, merchants, avowing the belief that the so-called capitalistic system of the present day is somehow inherently wrong. Few may be familiar with the scientific arguments of socialistic writers; but one hears everywhere the opinion that the vast accumulation and concentration of wealth is a public danger. There is a well settled belief that the possessors of wealth—those who live on the income of their property—are getting too much of the earth's product, while those who work with their hands or their heads are getting too little.

It is far from strange that people nowadays should hold such ideas. Nothing is more impressive among the economic changes of recent times than the enormous increase in wealth. Multi-millionaires are as common to-day as millionaires were a generation ago. Hundreds and thousands of families lavish money on expensive living where one did in the times of our grandfathers; and the stories of their wealth and luxury are blazoned abroad every day. Small wonder that social discontent is abroad in the land; nor is it remarkable that it should infect more or less all classes, from the lowest to the highest. It is unquestionably the flaunting of wealth before the public in ostentatious display—and particularly wealth gained by questionable means—that is most largely responsible for the steadily growing enmity toward wealth and property.

It is not well to be blinded, however, by such superficial manifestations of wealth. To a certain extent the question raised by the Socialist is a fair one and deserves fair investigation and an honest answer. Is the rapid increase of wealth a threat against the welfare of the people as a whole? If we concede, for the sake of argument, that payments for the use of capital are a burden—a fixed charge—upon production, it is reasonable to inquire how great has this burden become?

The U. S. Census Bureau has recently issued a volume containing information which, it seems to us, may be fairly made use of to test the claims of Socialism. The volume is entitled "Wealth, Debt and Taxation." It gives what is doubtless the most accurate and careful estimate ever made of the total wealth of the United States. The estimate is made for the year 1900 and the year 1904. In the former year the total value of all property in the United States is set at 88½ billion dollars. In the latter year the total was 107 billion dollars.*

These figures by themselves mean nothing. They are too huge for comprehension. But if it were possible to draw from them an approximate estimate of the total income which capital, or accumulated wealth, receives; and if we could then compare this income with the total earnings of labor, the comparison might contain some useful lessons.

Let us take first the task of estimating the total income which capital receives. The Census report before us classes the total wealth of the United States as follows:

Real property and improvements	$62,341,000,000
Live stock	4,074,000,000
Farm implements and machinery	845,000,000
Manufacturing machinery, tools and implements	3,300,000,000
Gold and silver coin and bullion	2,000,000,000
Railroads and their equipment	11,245,000,000
Street railways, shipping, water-works, electric light and power systems, telegraph and telephone systems and canals.	4,841,000,000
All other property—products of agriculture, manufactures and mines, merchandise, clothing, furniture, carriages and miscellaneous personal property	18,462,000,000

In our task of ascertaining the income on the invested wealth of the United States, we must recognize first that not all the wealth in the above table yields any income. Of course all the personal belongings included in the last item—furniture, clothing, provisions, etc.—are not invested and yield no income to their owners. These things are the product of combined labor and capital, all the time being poured forth and as rapidly being used up.

Again the above list includes all public property belonging to the Government, states, cities

*Throughout this discussion round numbers have been used in place of the exact figures of the official record, because the round figures are far more easily grasped and remembered, and the exact figures, being based on estimates only, add nothing whatever to the reliability of the conclusions.

and counties. It includes all public institutions, such as churches, hospitals, museums, art galleries, schools. It includes all the land owned by the Government and states and cities. All this property is held for public benefit; and where it produces an income, that income belongs to the public. Certainly, then, the Socialist should consent to deduct all this from the schedule of income-producing property.

The total amount of this public property, according to the census schedule, is $7,830,000,000. Adding this to the $18,462,000,000 worth of personal effects, we have $26,292,000,000 to be deducted from the total of $107,104,000,000, leaving $80,812,000,000 as the amount of possible income-producing wealth in the United States. Undoubtedly much of this property also produces no income, and much more produces very small returns; on the other hand this is offset by other property which yields large returns. In estimating this average rate of income yielded by property, we may well be guided by the returns on railway property since in that field the accurate statistics of the Interstate Commerce Commission are available. In 1904 the railways of the United States paid to their owners, the railway stock and bond holders, in interest and dividends the sum of $480,000,000 in round numbers, which was an average of 4¼% on the value of the railways given above.

It is doubtful whether real estate, which is seen above to constitute the bulk of the property of the United States, would show anything like as large an average return as the railways; but as we are aiming to find the maximum possible drain that capital may be making on the country, we will assume that railway capital represents a fair average of the rate of income produced by all wealth. On this basis $80,812,000,000 of invested capital at 4¼% would yield an annual return of $3,534,000,000.

And now let us turn and study the side of labor. The population of the United States on June 1, 1904, is placed by the census at 81,256,000. It was 76,000,000 in round numbers in 1900. The number of wage earners, or "persons engaged in gainful occupations," was given by the census of 1900 as 29,286,000. At the present time, therefore, this number must be swelled to some 31,000,000. We believe, however, that this is in excess of the true number of wage workers, as it includes those who are past the age of active work and those who are incapacitated for other reasons. A more accurate method, we believe, is to estimate one worker to each 3½ persons, which would give a total of 23,200,000 wage earners in round numbers.

What are the average annual earnings of these workers? For a guide in answering this question we turn again to the Interstate Commerce Commission railway statistics, and find there that in 1905 there were 1,382,000 men employed on the railways of the United States who received wages and salaries amounting to 840 million dollars, or an average of $608 per employee. Again, the Census report on Manufactures just issued shows that in 1905 there were in round numbers 6,000,000 persons engaged in manufacturing industries who received wages and salaries amounting to $3,186,000,000, or an average of $531 each. Similar statistics are not available for other occupations; but it will probably be generally agreed that the 1½ million persons engaged in professional occupations receive a higher average than this, while the 10½ millions engaged in agricultural and the 5½ millions in domestic and personal service receive considerably less. All things considered, $450 per annum seems as low a figure as can reasonably be estimated as the earnings of the average worker.

Multiplying now the total number of wage earners found by these average earnings, we have the total compensation paid to labor in a year at $10,340,000,000.

If these figures be accepted, then it appears that capital is now receiving about one dollar where labor is receiving three; or, to put it another way, if the annual product of the country is divided into four equal heaps, capital is getting one of these heaps and labor the other three.

It may be said that this conclusion is based on only an approximate estimate; but a little study will show that the basic figures of the estimate cannot be changed enough to materially alter the general conclusion. If the average net income yielded by property should be as much as 5%, and the average worker's annual earnings as low as $400, it would still remain true that labor and not capital is getting the bulk of the products of industry.

This conclusion can be substantiated, however, in other ways. Everyone familiar with business affairs knows that in almost every industry the annual pay roll is several times as large as the amount which the owners of the business can draw out in profits. In the railway industry exact statistics are available and were quoted above, viz., annual payments to security holders of $480,000,000 compared with annual payments of 840 million dollars. Here the proportion is slightly less than 1 to 2; but in railway transportation there is a larger investment of fixed capital required per employee than in almost any other industry. The figures above given were: Capital in railways, $11,245,000,000; number of employees, 1,382,000; average investment per employee, $8,140. In contrast with this are the conditions in agriculture where two or three men are required to do the work on a farm worth perhaps $5,000. Remembering that some ten millions of the wage earners of the country are engaged in agriculture, it is an inevitable conclusion that our estimate of 1 to 3 as the proportional distribution to capital and to labor errs if anything by giving a larger return to capital than it actually receives.

But in making this comparison between the earnings of capital and the earnings of labor; we must be careful not to make the common mistake of identifying capital with wealth and labor with poverty. A large part of the 107 billion dollars of wealth in the United States is actually the property of the wage workers themselves. The huge accumulations of wealth by the few multi-millionaires bulk large in the popular mind; but they are really small compared with the accumulated savings of the millions of people of moderate means. The deposits in the savings banks of the United States last year exceeded $3,482,000,000. That this is the property of people of small means is well known to every one, and is practically proved by the fact that the average size of each deposit is only $433.79. The assets of life insurance companies, totaling over $2,700,000,000, are likewise chiefly made up of the savings of those of small means. The farms of the United States are valued at $16,615,000,000, and 5,690,000 families live upon them, giving an average holding per family of only $2,920.

Wealth that is so widely distributed certainly contains no threat against the public welfare and gives no foundation for the arguments of the Socialist. He must confine his agitation against property to the holdings of the wealthy if he would command a hearing. The preceding discussion shows that the total holdings of those that may be classed as wealthy must be only a part and probably a small part of the existing $80,812,000,000 of income-producing wealth.

To test to the utmost the claims of the Socialist, however, let us make no deductions and let us suppose that the wildest dream of the most radical opponent of property rights is realized—the dream that all the income which now goes to capital should be divided equally among all those who labor. Let us suppose that all existing wealth is confiscated and distributed among all wage earners. Suppose that when so distributed it is still as productive of income as it is at present. Suppose the workers in such a revolutionized social order could exert their energies and reap the same return as now in the shape of wages. If all these stupendous changes could be brought to pass, then the average wage earner who now earns $450 per annum would receive about $150 additional, or about 50 cts. per day, as his share of income on the accumulated store of capital.

The lesson in these figures is not new. It has again and again been shown that no matter how huge wealth may look in the aggregate, general distribution could not make everybody wealthy, or even abolish poverty. It could only to a very slight degree lighten the task of the worker or increase his comforts.

It need hardly be said that the wrench necessary to effect such a social upheaval and broadcast confiscation and distribution of wealth would in all probability upset the whole machinery of production and condemn millions to starvation. Even after a semblance of order was brought out of chaos, it has never been demonstrated how the remodeled society which the Socialist would establish could compare in productive efficiency with that now in operation under the present capitalistic system.

But it may be asked whether the phenomenal rate of *increase* of wealth does not contain some threat against the public welfare. The Census statistics show an increase of wealth of 21 billion dollars in the four years from 1900 to 1904. Even though capital may now receive only a small part of the industrial product, may not the increase of wealth reverse these conditions and leave labor with the smaller portion?

In the first place there are good reasons for the present rapid increase in wealth. With capital and labor both receiving returns, in this prosperous and favored country, vastly larger than have ever been recorded anywhere in the world, it would be a pity indeed if a large proportion of these returns were not saved and invested in some permanent form instead of expended on the gratification of daily desire.

Let us follow out the results of the saving and investment of capital. It results, in the first place, in lowering the current rates of interest and of income on all invested capital, and thereby lessens the share which capital can take of the total annual industrial product. The importance of this matter deserves emphasis. Hardly a generation ago, invested capital commonly received a return of 6% to 7%. The enormous increase in saved wealth seeking investment has lowered this return to 3% or 4%. That means that within a generation the returns to capital have been practically cut in two. That means, to take a concrete example, that in an industry carried on in a factory costing say $100,000, not more than half as much has to be paid as rental for the factory as was paid a generation ago.

It is true, of course, that the increase in wealth —in capital—is intimately related to the use of labor-saving machinery and to the introduction of all the vast array of the comforts of life of which the world knew nothing a brief century ago. In the last analysis, capital can only find profitable investment by making labor more efficient. If capital builds a railway, it substitutes steam power for animal traction, and enables the men who operate the railway to transport a thousand tons a mile with no more time spent than would be required to haul two tons by animal traction. Capital, in fact, is the barrier between the world and the hand-to-mouth existence that typifies the savage state. Every tool used in production, from the crudest stone implement of the prehistoric man to the apparatus in a modern electric power station, actually represents capital.

If this fact is clearly grasped, it will then be clear also that the present day increase in wealth is intimately connected with the efficiency of labor made possible by the use of labor-saving machinery. Or to put it in another way: It is only because accumulated wealth has increased to such a point that its annual income amounts to over three billion dollars that labor is now able to reap over ten billion dollars from a year's industry.

If one desires proof that the investment of capital in machinery to make labor more efficient has actually revolutionized the condition of labor, one needs only to view the condition of labor and of capital a century ago, at the beginning of the industrial era. Labor then fought every attempt of capital to introduce labor-saving machinery, foreseeing diminished wages or loss of employment and failing to discern that the greater the product a workman could produce by the aid of machinery, the greater the wages he could earn; while the constantly growing wants and desires of the race would furnish new

avenues of employment for the workers temporarily displaced.

The average laborer a generation ago earned a lower wage and lived under poorer conditions by far than the lowest class of labor to-day would dream of accepting.

There is, however, one factor in the increase of wealth which may rightly be looked on with some concern. That is the growth in value of monopolized gifts of nature, the mineral deposits, waterfalls, and fortunately situated lands, and other natural or artificial monopolies which have in recent years grown up. That some part of the modern increase in wealth is due to "unearned increment," gained through these methods, will, of course, be conceded.

Our present social organization, however, is entirely competent to remedy these abuses of the rights of property, and to do it with no such resort to revolutionary methods as the Socialist proposes.

That future progress will tend toward a wider distribution of wealth—the end which the Socialist would reach—may well be believed. That the total wealth will increase with the increase in population and that the wealth per inhabitant will grow with the steady growth in the use of machinery and the consequent increase in the effectiveness of labor is also certain.

LETTERS TO THE EDITOR.

What Bearing Pressure on Concrete Footings is Allowable?

Sir: We have lately had under consideration the question as to what safe load per square inch may be applied by a structural iron column upon a reinforced-concrete footing, and we have found many authorities that give this safe load all the way from 200 to 1,500 lbs. per sq. in. The case under consideration is an 8 x 8-ft. reinforced-concrete footing 22 ins. thick, upon which we are to place such size baseplate as may be necessary to carry a given load on the column. It appears that the safe load, so far as the shear is concerned, may be sufficient to place about 1,500 lbs. per sq. in. load on the footings. If the matter is worthy of consideration, we would be pleased to see the subject covered in your paper, as there appears to be no agreement between different authors as to what is a safe load for such construction.

Respectfully,

Bartlett & Kling.

Cedar Rapids, Iowa, July 15, 1907.

A Diagram for T-Shaped Beams of Reinforced Concrete.

Sir: It is without any doubt that in reinforced-concrete floors, a part of the slab increases the resistance of the beam, when beam and slab are built as one piece. This effect should be considered in computing reinforced-concrete beams or retaining walls. As to what part of slab is to be considered in the formula, there are differences in opinions and practice. While German practice takes the whole span between two adjoining beams as working with the beam, the French government rules recommend using not more than three-quarters of that length; many engineers in this country will find both rather excessive. In any case the designing engineer has to use his own judgment in selecting the working width of the slab.

The formula for T-shaped beams is rather complicated and cannot be reduced to a simple form. This may be a reason why it is not generally adopted.

In the following, the straight-line formula is employed. It is assumed that the steel takes all the tension, while compression is taken by the flange or slab alone. Under the assumption that the stresses in concrete and steel shall not exceed 500 lbs. per sq. in. and 16,000 lbs. per sq. in., respectively, and that the ratio of elasticity of steel and concrete is $n = 15$, we obtain the known expression for resisting moment

$$M = \tfrac{1}{2}\, bt\,(c + c')\,(h - d)$$

where, referring to Fig. 1,

b = working width of slab.
t = thickness of slab.
c = stress in upper fiber of the flange.
c' = stress in lower fiber of the flange $= c\,\dfrac{x - t}{x}$.
$h - d$ = effective depth of beam.
d = distance of center of gravity of compressive stresses from upper face of slab $= \dfrac{t}{3}\,\dfrac{c + 2c'}{c + c'}$.
x = distance of neutral axis from upper face $= \dfrac{n\,c}{n\,c + s}\,h = 0.319\,h$ [for $c = 500$, $s = 16{,}000$, $n = 15$].

Fig. 1.

Substituting the values for c, d and x in the equation for M, we obtain:

$$M = 250\,b\,t\left(2h - 4.135\,t + 2.00\,\frac{t^2}{h}\right).$$

The diagram, Fig. 2, was drawn from this equation. In order to find the required depth h for a given bending moment M, we have to assume a working width of slab b; then the line corresponding to thickness of slab will immediately give the depth h. For slab thicknesses between values given by curves, interpolation gives the result without any appreciable error.

It will be noticed that the diagram gives only values of h above a certain fixed depth h for a given curve of t, because for all values of h below that depth the neutral axis falls inside the slab and in that case h is to be computed from the formula for rectangular beams.

The set of lines in the left-hand corner of the diagram gives the amount of steel required for T-beams, at 16,000 lbs. per sq. in. It is based on the formula

$$A = \frac{M}{s\,(h - d)}$$

where:

A = area of steel in sq. ins.
M = moment in in.-lbs.
s = unit stress in steel = 16,000 lbs. per sq. in.

Example 1.—To find depth h of a beam with a slab thickness $t = 4$ ins., to resist a moment of 1,800,000 in.-lbs. We have to select the working width of slab, say $b = 50$ ins. Then $\dfrac{M}{b} = 1{,}800{,}000 \div 50 = 36{,}000$ in.-lbs.

Following the vertical from 36,000 on bottom scale up to the line corresponding to $t = 4$ ins. we obtain $h = 25$ ins. The reinforcement required is obtained by following the horizontal from $h = 25$ to the line of reinforcement for $t = 4$. It gives 0.0935 sq. in. as the reinforcement for $b = 1$ in., or total reinforcement $A = 0.0935 \times 50 = 4.675$ sq. ins.

Example 2.—When for any reason the depth of the beam is limited we are able to find the corresponding b and see if it is still within allowable limits. Thus, for instance, if in the foregoing example the depth h is limited to 23 ins., we will find from the diagram that the corresponding moment for $b = 1$ in. is now 31,000 in.-lbs. and consequently $b = \dfrac{1{,}800{,}000}{31{,}000} = 58$ ins. instead of 50 ins.

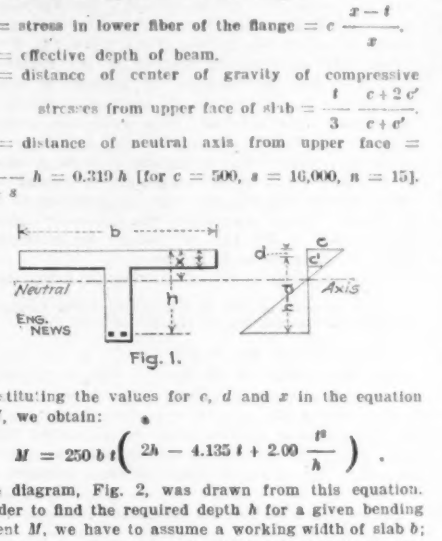


FIG. 2. DIAGRAM FOR DEPTH AND REINFORCEMENT OF REINFORCED-CONCRETE T-BEAMS.

If it is required that b should not exceed 50 ins. we find, by following the horizontal line from $h = 23$ to $\dfrac{M}{b} = 36{,}000$, that an increase of slab thickness from 4 ins. to at least 5 ins. is necessary in order to resist a moment of 1,800,000 in.-lbs. The amount of steel in both cases is to be found as before. For $t = 4$ ins. and $b = 58$ ins. we need $A = 0.0905 \times 58 = 5.249$ sq. ins., while for $t = 5$ ins. and $b = 50$ ins., A is equal $0.102 \times 50 = 5.10$ sq. ins.

M. Nikolitch.

2832 California St., San Francisco, Cal., June 14, 1907.

Web Stresses in a Plate-Girder with Abrupt Change of Depth.

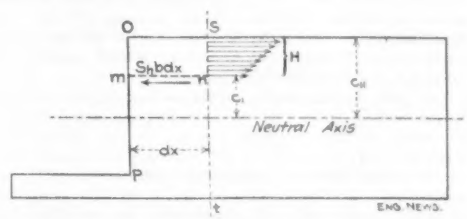
Sir: In your issue of June 27, P. L. Girder brought up for discussion a type of beam, which, while quite common, is not usually discussed in text-books.

If the elastic limit of the material is not exceeded, the stress may be obtained by the following formula:

$$S = \frac{Mc}{I}, \text{ where}$$

S = flexural unit stress at farthermost fiber of any chosen section,
M = moment at that section,
c = distance from center of gravity of section to outermost fiber at given point,
I = rectangular moment of inertia for this same section about center of gravity.

Stresses at other points of this section will of course vary directly as their distance from the neutral axis. The units of weight and of distance must necessarily be the same throughout.



We will next examine the shearing stresses.

Let b = the average thickness of the beam on the section mn and let dx = the distance from OP to any section st. Now if the section $Osnm$ be imagined removed, the flexural forces marked H and the horizontal shear on surface mn will be needed to preserve equilibrium.

Let S_h = unit horizontal shear on plane mn
then $S_h b dx$ = total horizontal shear on plane mn
but $H = S_h b dx$ (to be in equilibrium)

but from above,

$$H = \frac{M}{I}\sum \frac{c_{11}}{c\ c_1}$$

$$\frac{M}{I}\sum \frac{c_{11}}{c\ c_1} = S_h\, bdx$$

$$\text{and } S_h = \frac{\dfrac{M}{I}\sum \dfrac{c_{11}}{c\ c_1}}{bdx}$$

But dx approaches zero as a limit, while

$$\frac{M}{I}\sum \frac{c_{11}}{c\ c_1}$$

is constant for any one plane, that is, it is finite. Therefore the shearing unit stress becomes infinitely great at all points on the line OP, being a fraction with a finite numerator and a zero denominator.

Since the preceding formulas do not hold for stresses beyond the elastic limit, the foregoing work is of value only as showing that this amount has been exceeded.

What undoubtedly does happen is that when the stress surpasses the shearing elastic limit, the material towards the corner O gives, and the moment that it bears is such as may be transmitted by a shearing stress beyond the elastic limit but less than the ultimate strength.

As the beam violates the sound engineering principle that the elastic limit should not be exceeded, actual amount of stress is not necessary to secure its condemnation.

Horace R. Thayer.

712 South Linden Ave., Pittsburg, Pa., July 5, 1907.

Live Load Moments in Highway Bridges Carrying Road Rollers.

Sir: Referring to the communication in your issue of July 4th, by Mr. John Howard Ford, I would like to point out that the maximum moment due to a road roller is simply a case under the general proposition of a series of concentrated loads. Mr. J. C. Bland gave a general formula in Engineering News, Feb. 2, 1884, covering all cases. The maximum moment will occur under a heavy load near the center of span. The loads are to be placed so that the center of span comes half way between the center of gravity of the system of loads and the load under which the maximum moment occurs. Mr. Bland gave a general formula, which will be found in my book of "Tables," page 43. On the same page special cases of one, two, three loads, etc., are given, showing the position for maximum moment. The position of two loads, as worked out by Mr. Ford, is there shown, and it is stated, as hinted at by Mr. Ford, that, when the distance between two equal loads exceeds 0.5858 times the span length, one load placed at the center of span gives the maximum moment.

In practice it is generally considered accurate enough to take the maximum moment at the center of span due to the uniform load and add it to the maximum due to the concentrations, though both do not occur at the exact center of span. The uniform load is generally small in comparison with the concentrated load, and the slight difference between the results obtained by this method and the absolute maximum is too small to justify the complex calculations of the exact method, especially as the difference is on the safe side.

Yours very truly, Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., July 10, 1907.

Cost of Highway Maintenance in Colorado.

Sir: I have previously overlooked your interesting comparison of the cost of roads in Colorado with those in England, given on p. 355 of the previous volume of Engineering News. You have shown that the cost of road maintenance in this state, of from $20 to $40 per mile, compares with a cost in a densely settled country in England of $600 to $800 per mile.

The cost in this state, however, has nearly doubled in the past six years, and this represents an actual change in public sentiment toward roads. To one who is acquainted with the state it is not necessary to remind them of the large expanse of roads in comparison with the population. An explanation of the small cost per mile is partly in this fact, and consequently the inability of a community to maintain the roads which are laid out, and also partly because of the fact that a large part of the roads which are laid out are so situated and under such natural conditions that almost no expense is required for their maintenance. The rainfall being small and the ground gravel or porous there are miles and miles of road which require no expenditure upon them at all.

Of the expense in the irrigated section, a considerable portion goes for culverts and small bridges, and the maintenance of roads where the expense is increased, due to the wet grounds from seepage. In other places the expense of maintenance is frequently only that which is due to washing from rains.

It is undoubtedly true that there will be an increase in the future in cost of maintenance, due to the fact that most of the roads which are needed as ways of communication are already laid out, and now the tendency will be to make better roads as public sentiment now requires it. Many of the counties are now provided with road graders, several counties having several, and work is being done better than ever before. The growth in the automobile interest also has much to do with the making of better roads.

Respectfully yours,

L. G. Carpenter.

Fort Collins, Colo., July 8, 1907.

Friction in the Gate Operating Mechanism of Hydraulic Turbines.

Sir: In the "Zeitschrift des Vereines Deutscher Ingenieure" of Dec. 15, 1906, p. 2030, R. Camerer calls attention to the remarkable increase in twisting moment on the gate operating spindle of a turbine fitted with Fink gates, when the moment is first calculated with reference only to the hydrostatic pressure on the gates, disregarding friction and recalculated, including friction. For one position of the gates, without friction, the spindle moment is 59.6 Kg. m. For the same position with 15% and 30% friction, respectively, the moments are 596 Kg. m. and 1,708 Kg. m. By referring to the article mentioned, the method of calculating these moments may be examined if desired. The corresponding thrusts on the spindle are: 59. Kg., 87. Kg., and 133.8 Kg. Mr. Camerer calls attention to the interesting fact that with 15% and 30% friction, there are corresponding increases in thrust of 47½% and 126½% and corresponding increase of spindle moment of 900% and 2,762%, respectively.

The question which rose in the writer's mind upon reading these large increases in moment was: How is this great loss in friction distributed? Upon making an examination of the calculations it will be found that, by far, the greater portion of it is due to the screw thread and the screw step of the spindle. For example: take the conditions for 15% friction (for both axle and sliding.) Disregard the friction of the screw and it will be found that the resulting moment on the spindle is 88 Kg. m. Thus the increase in moment is only 28.4 Kg. m. for the friction in all pins and links excepting the screw. Now calculate the moment due to the friction of the thread, the data being: thrust on spindle = 87 Kg., mean radius of spindle = 16.25 m. m., pitch of threads = 6.35 m. m., coefficient of friction = 0.15. The result is 214 Kg. m. The mean radius of step is 22½ m. m. Hence the moment due to spindle step is 87 × 0.15 × 22.5 = 294 Kg. m. Hence we distribute the various friction losses as follows:

Increase in moment due to all friction except in screw	28.4
Increase in moment due to friction in screw thread	214.0
Increase in moment due to friction in step	294.0
Total moment due to friction	536.0

This shows that of all the loss due to friction, for this position of the gate with 15% friction, 508 ÷ 536 of it, or about 95% of it, is caused by the friction of the spindle. Hence it appears clear to the writer that the gate operating spindle is responsible for the most noticeable part of the friction and effect produced by it.

B. F. Groat.

University of Minnesota, Minneapolis, Minn., July 5, 1907.

Some Practical Experience with Centrifugal Pumps for Water-Works Service.

Sir: In your report of the proceedings of the American Water-Works Association at Toronto (Eng. News, June 26, 1907) you refer to the writer's remarks concerning centrifugal pumps, in a good-natured tone of sarcasm which tempts reply. You of course understand that the writer is not responsible for the fact that 2 and 2 make 4, and also that such a numerical result has stood the test of time and likely will continue to be the correct record for some time to come. The one excuse for attempting to live, upon the part of the centrifugal pump, so far at least as concerns water-works pumping, is low first cost of plant; and it goes without saying that the machine, for any certain purpose, of the lowest first cost with all other balances at least equal, will prevail; but this brings us to a realization of the further fact that the present prominence of the centrifugal pump is simply due to a reversal of the arguments of 25 years ago, when the high duty steam pumping engine with its higher first cost forced its way to the front by the showing of the capitalized value of its reduced coal account, as compared with the cost of fuel necessary to maintain the power of the low duty pumping engine. The main difference between the increased interest, maintenance, and sinking fund of the high duty engine of a quarter of a century ago and the decreased items of the centrifugal machine of to-day, is that the high duty reciprocating pumping engine rapidly and conclusively proved its case, while the present centrifugal pump has so far failed in so doing, and to all appearances never will be able to acquire and maintain the leading position as an apparatus for pumping water with acceptable economy under every day pressures and conditions of municipal supply.

The writer has had to do with, and has tested, centrifugal pumps in water-works plants, but from observations so made can see no hope of such machinery successfully competing, in anything but first cost of plant, with the reciprocating type of apparatus, under ordinary water-works conditions. The fallacious advantage of apparent low initial cost really places the centrifugal pump back in the low duty class of several years ago, from which the water-works plants have just about worked clear, after a long and expensive experience. The present issue seems to be commercialism against engineering, with the buyer's interest secondary. The friends and exploiters of the centrifugal pumping plants talk glibly about 80% test efficiencies and of 75% everyday efficiencies, but in the hands of disinterested people, intent only upon learning the facts, the 80% shrinks down to about 65%, and the ordinary efficiency sinks to a little over 50% of the power applied.

Under low heads, and with comparatively small quantities of water, where the revolutions per minute of the centrifugal pump come down within reach of direct-connected steam or gas engines, the working economy is satisfactory; but with the high rate of revolution under which the centrifugal must be worked to meet say 200 ft. head of water or more, either a belted machine, a steam turbine, or an electric motor, must be employed, and such applications of power have not so far been able to compete in economy of operation with the reciprocating steam pumping engine. Such examples may be found in service at a cost of $9,000 per annum for a pumpage of 4,000,000 gals. per day by centrifugal pumps operated by electricity, as against $16,000 per annum for coal for 14,000,000 gals. of water delivered per day by steam pumping engines. This means that with both plants reduced to a 4,000,000-gal. basis, the reciprocating machinery would earn 5% per annum on the sum of $87,600; and with both plants on a 4,000,000-gal. basis, the reciprocating steam plant would earn 5% per annum on $310,680. This may look like an extreme comparison, but the gross records of water pumped and money paid for electric current and for fuel are plain enough. A 4,000,000-gal. horizontal cross compound steam pumping engine, giving a steam duty of 100,000,000-ft.-lbs. per 1,000 lbs. of steam (and this ought to be easy enough these days) will pump 4,000,000 gals. of water per day against 100 lbs. water pressure with an expenditure for fuel per annum of $5,201, with coal at $3 per net ton, and an actual evaporation of 8 to 1 in the boilers. The difference between this result and $9,000 per annum for the same amount of water pumped by electrically driven centrifugal pumps will pay 5% on $75,980, and the cost of a steam pumping plant, including buildings, chimney and everything except the land, at $10,000 per 1,000,000 gals. capacity, which would be high, amounts to only $40,000 for a 4,000,000-gal. plant.

The discrepancies in the above comparison are very great against the centrifugal pump, but aside from the inherent comparative disability it is becoming manifest that impellers wear rapidly in centrifugal pumps, when under high velocity and considerable head.

The paper at the convention which brought out this discussion referred to records of a falling off of 12% in the delivery of water due to the wearing of the impeller, as compared to the calculated or calibrated capacity of the machine when new. The writer knows of a case wherein two 12,000,000-gal. electrically driven, single-stage centrifugal pumps were installed to work against 257 ft. head, the contractor having the utmost confidence of success before the pumps were put into place. The pumps absolutely failed to deliver satisfactorily against the head, and then two-stage pumps were substituted. The latter were more successful, but after several months' operation it required both pumps to deliver the required quantity of water, although one of the pumps was supposed to have a margin of one-third its capacity above the regular demands; and the water pressure maintained averaged only about 80% of that required by the contract. These two-stage pumps, which followed the single-stage pump, are now being replaced by other centrifugals, of a different design and make.

Another case is recalled wherein a pumpage of 10,000,000 gals. per day against 110 lbs. load was required, and which could be easily accomplished with reciprocating steam machinery by an expenditure of $10,000 per annum for coal, but where an attempt to drive centrifugal pumps by electricity would result in a cost for electrical power, at $6.50 per 1,000,000 gals., of $23,725 per annum; showing a difference in favor of steam that would pay 5% per annum on $275,940. There is no conceivable difference in cost of machinery, buildings, maintenance, attendance, or anything else that would justify such a preference for electricity and centrifugal pumps over steam and recriprocating pumps. There is no mystery about the matter, as may be seen by the following facts:

10,000,000 gals. against 110 lbs. pressure = 120,000,000 steam duty, with 8 lbs. evaporation in the boilers, and with coal at $2.50 per net ton delivered	440 pump HP.
	$9,928 per annum
Electric power at $6.50 per 1,000,000 gals. means 3,650 million gallons per annum at $6.50, amounting to $23,725	$23,725 per annum
The difference in cost for the elements of power is $13,797, which at 5% would capitalize at	$275,940

The electrically driven, centrifugal plant was tried, commencing about three years ago, and it is safe to say that everyone is disappointed in the results, and it is whispered that although the contract was executed in the autumn of 1903 no money has yet been paid to the contractor.

Coming directly to a comparison between electrically driven centrifugal pumps and reciprocating steam driven pumping engines in the Buffalo water-works, as set forth in the particular paper before the convention, it seems to the writer that a much more equitable comparison, and one more in line with the interests of the buyer, would be as follows:

COST OF OWNING AND PUMPING WITH THE HIGHEST TYPE AND CLASS OF STEAM MACHINERY.

One unit of 25,000,000 gals. against 87 lbs. (200 ft. head.)		
Pump horse-power		870 HP.
Vertical triple expansion pumping engine, 450 boiler HP. of boilers		
Engine house and foundations, and engine foundations		$150,000
Boiler house and foundations, and boiler foundations		
Coal storage building		
Pumping engine:		
	Interest	4%
	Sinking fund	5%
	Depreciation	2%
	Oil, waste, etc.	1%
	Total	12%

Boilers:	
Interest	4%
Sinking fund	5%
Depreciation	5%
Total	14%

3 Engineers; 6 Firemen; 3 Oilers; Coal, $2.10 per net ton.

Summary for steam, reciprocating machinery.

Coal per annum	$11,957.40
Wages per annum	9,900.00
Capital charges on engine	13,920.00
Capital charges on boilers	1,260.00
Capital charges on buildings	1,548.00
Total charges per annum	$38,585.40

Cost per 1,000,000 gals., $4.11.
Cost per horse-power, $43.16.

COST OF OWNING AND PUMPING WITH THE HIGHEST TYPE OF ELECTRO-TURBINE PUMPING MACHINERY.

One unit of 25,000,000 gals. against 87 lbs. (200 ft. head.)
Pump horse-power 870 HP.

Two stage, electrically driven turbine pump, Engine house and foundations, and pump foundations	
Transformer house and foundations, Auxiliary house and foundations, Transformers, lightning arresters, conductors, controllers, and all auxiliary apparatus	$43,750
Pumping machinery, motors, etc.:	
Interest	4%
Sinking fund	5%
Oil, waste, etc.	1%
Depreciation	2%
Total	12%

3 Engineers; 3 Extra men; Electric power at Buffalo, $4.50 per 1,000,000 gals.

Summary for electro-turbine pumping machinery.

Electric current per annum	$41,062.50
Wages per annum	5,700.00
Capital charges on machinery	4,314.00
Capital charges on buildings	468.00
Total charges per annum	$51,544.50

Cost per 1,000,000 gals., $5.64.
Cost per horse-power, $59.24.

The steam plant saves enough to pay 8.6% on entire cost of steam plant. Electric power must be sold at Buffalo at $3 per 1,000,000 gals. to balance the steam plant account, and the depreciation charge of 2% is very probably too low for the electro-turbine apparatus, according to experience so far; while 2% is perfectly safe for the steam plant depreciation so far as the engine is concerned, and the sinking fund of 5% is likely 2% too high for the steam plant, while 5% is very likely too low for the electro-turbine machinery for sinking fund. All of the certainties are in favor of the steam and all of the chances are against the electricity.

Yours respectfully,
Chas. A. Hague.

52 Broadway, New York, July 1, 1907.

Wave Action on Breakwaters.

Sir: In connection with Lt.-Col. Townsend's very interesting communication on the injury to the Cleveland Breakwater due to a severe storm, published in Engineering News, June 20, 1907, I submit the following observations on the effect of storms on the Point Judith Breakwater.

The main breakwater of the Point Judith Harbor of Refuge is of the rubble mound type, having a top width of 20 ft. at an elevation of 10 ft. above the plane of mean low water, the rise and fall of the tide being about 4 ft. The exterior slope was designed to be 1 vertical to 2 horizontal from the top to depth of 12 ft. at low water, from thence 1 on 1 to the bottom; the interior or harbor slope 1 on 1. After an exposure of 8½ years the average exterior slope is practically 1 on 2 above the low water plane and approximates to 1 on 1½ below that plane and the harbor slope is slightly flatter than 1 on 1. These figures apply to the Eastern Arm of the breakwater which is exposed to the heaviest sea. This exposure is greater than at any point of the coast of the United States at which a breakwater has been built excepting the site of the Cape Ann breakwater, where work is now in progress, and the northwestern coast of Oregon and Washington.

Major Townsend ascribes the displacement of stones on the harbor side of the Cleveland Breakwater to the action of the wave on one side of an arch formed by the paving or stones forming the top, with a resulting displacement of the stones on the other side; rather than to the transmission of the energy of the breaking wave through the structure and its manifestation on the harbor side by the displacement of stones there.

In the "Polytechnic" (a journal published by the students of the Rensselaer Polytechnic Institute) of Oct. 5, 1905, I contributed an article on the Point Judith Breakwater which briefly discussed the feature of the transmission of the wave energy through the structure which, so far as I am aware, is the first published allusion to this feature of damage to breakwaters, and I take the liberty of quoting the following from that article:

The manner in which the wave force may be exerted against a structure such as the Point Judith Breakwater is complex. The chief destructive effect has been the carrying away of small portions of the harbor slope, which occurred at three points on the eastern arm * * *. The writer has measured waves 15 ft. high off Point Judith, but this was not in a storm of great severity, so that it is probable that in a severe storm waves of greater height break on the structure, these falling on the interior slope assisted by the pressure transmitted under and on the sides of the individual stones, those on the interior might be said to be floated from their positions and rolled down the slope.

The expression "floated" referring to that condition in which the stone is practically borne up by the film of water under it, this being under sufficient pressure to neutralize the friction between the stone and those lying adjacent to it. The conditions being such that, for the moment, all of this transmitted pressure could be exerted on the bottom or vertical sides of the stone but not on the top. Such a transmission of energy would readily account for the removal of such masses as the 2,600-ton monolithic pier head of the Wick Breakwater in England in 1877. As a further direct evidence of the transmission and change of direction of the energy imparted by the wave, there are on the Point Judith Breakwater three stones that have been lifted bodily from their beds a vertical distance of about three feet and placed along side of them on the top of the breakwater where there has not been force enough since from the direct action of the waves to dislodge them. The position on top of the structure above the point of application of the maximum blow is probably the reason for their retaining their positions.

The process seems to me to be that the blow is applied to the front of the structure with all the interstices filled with water and is immediately transmitted to the back where if the conditions are favorable it displaces the last or unsupported stone. The question would naturally arise then as to why the whole breakwater was not blown to pieces every time a severe storm arose. It is not destroyed for the reason that there is, in a rip-rap structure, an unlimited number of vents available for the dispersion of the wave energy. That these displacements are comparatively rare is evidenced by the fact that there are perhaps a dozen well marked instances in a breakwater 6,940 ft. long after an exposure of 8½ years.

In the rubble mound type of breakwater there would be very small chance of the arch formation described in the Cleveland Breakwater. The 20 ft. wide top at Point Judith is usually formed of two irregularly shaped stones from two to three feet in thickness, weighing from 10 to 15 tons, with smaller stones roughly filling the spaces between, and while it is not of the type most generally advocated in recent years, it has effectively performed its work at a minimum of cost, requiring thus far the expenditure of less than $7,000 for repairs on a structure costing $1,250,000.

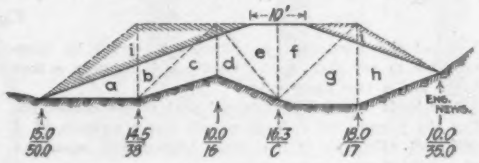
Very respectfully,
Edward Parrish,
Ass't Engineer, U. S. Engineer Office.

Newport, R. I., June 25, 1907.

A Simple Earthwork Formula and Tables.

Sir: From time to time new "Earthwork Formulas," diagrams or tables are recommended by your patrons, and the writer never sees a communication on this subject without a sense of sympathy for those unfortunates in the engineering profession who are not acquainted with the simple tables constructed about 20 years ago by Mr. S. Elliot Moore, suited to any cross section and largely in use on the Mississippi levees.

By adding together a few quantities read directly from these tables and making a subtraction, the cubic yards in any 100-ft. station can be found provided the cross-section notes for its two ends are at hand. In case of a shorter distance between cross-sections, such per cent. of the tabular result is taken as the treated distance is of 100 ft.



The basis for these tables is the simple axiom that the whole is equal to the sum of all of its parts. Let A be the area of the cross-section shown, which for simplicity is taken with 10 ft. crown and 1 on 3 slopes. Let B be the area of the next cross-section 100 ft. away. The quantity in the station, in cubic yards, is

$$\frac{A+B}{2} \times 100 \div 27 = \frac{A \times 100}{2 \times 27} + \frac{B \times 100}{2 \times 27}.$$

But A is made up of the sum of a lot of triangles (the bases and altitudes of which can be read directly from the cross-section notes), minus the sum of the triangles beyond the slope lines, but within the dot and dash lines, or

$$A = a + b + c + d + e + f + g + h - (i + f)$$

$$\therefore \frac{A \times 100}{2 \times 27} = \frac{a \times 100}{2 \times 27} + \frac{b \times 100}{2 \times 27} + \text{etc.},$$

which looks like a cumbersome formula, but the table comes in here. The area of each triangle is half the product of the fill forming one of its sides, by the distance from that fill to the next. Each "minus" triangle is half the product of the extreme fill by the distance from the edge of the crown to the last intermediate. Taking the cross-section notes corresponding to the sketch, it will readily be seen that the area of the cross-section is (beginning at the left)

$$\frac{14.5 \times (50. - 16.)}{2} (= a + b) + \frac{10.0 \times (38. - 0.)}{2} + \frac{16.3 \times (16 + 17)}{2} + \frac{18.0 \times (35. - 0.)}{2} - \frac{15.0 \times (38. - 5.)}{2} (= i) - \frac{10.0 \times (17. - 5.)}{2} (= f).$$

In using the table, read 14.5 by 34.0 (one of the factors being in the left column and the other at the head of the page). The result is, in cubic yards, $\frac{(a+b) \times 100}{2 \times 27}$; and so read from the table for 10.0 by 38.0 a quantity which represents $\frac{(c+d) \times 100}{2 \times 27}$.

After using this table for two hours, one can read the partial quantities out of it as rapidly as he can read the fills and distances from his cross-section notes. Having added together the four plus quantities read from the table, and subtracted therefrom the two minus quantities, the result is, in cubic yards, $\frac{A \times 100}{2 \times 27}$. Read the quantities off in the same way for the "B" section, add the two together and the result is the contents of the station to the nearest tenth of a yard. Carry the B result forward to add to cross-section "C," etc.

No engineer who has used these tables for a day, on complicated cross-sections, will ever be reconciled to any of the alternatives that I know of.

Respectfully, A. L. Dabney.

738 North Third St., Reading, Pa.

[In an editorial in the Engineering Literature Supplement to Engineering News for Jan. 15, 1903, a review of the various tables for earthwork computation is given in which this set of tables is noted.—Ed.]

A Suggested Development in Railway Track.

Sir: In regard to Mr. J. W. Schaub's paper on "A Suggested Development in Railway Track," published in your issue of June 13, it might be pertinent to suggest a few difficulties which would be encountered in maintaining his proposed type of track.

His final construction is a bed of concrete 16 ins. thick, probably 10 ft. wide, upon which sized wooden ties are laid. It is practically impossible to produce treated ties which will not shrink, split, warp or otherwise get out of shape. It is also out of the question to size them after treatment, as that would remove a portion of the more thoroughly treated outer shell of the wood and therefore encourage its destruction. It would also be somewhat difficult to size untreated ties and keep them an exact depth when exposed to the weather while held in stock to replace ties to be removed, as different growths of even the same wood will respond differently to the action of the elements. A difference of ¼-in. in depths of ties laid on a concrete foundation would be very noticeable in the surface of such track. Should the ties become cut by the rail or worn by friction as much as ¼-in. to ½-in., which is not uncommon, it would not be practicable to put in a new tie of the exact original depth unless adjacent ties were shimmed or the new tie adzed.

Then who can say that such a bed of concrete can be constructed without the variation of ¼-in. to ½-in. in surface in a rail length, and such a variation would absolutely prevent the attainment of anything except the roughest of track. The concrete bed is an impossible construction for new railways owing to the shrinkage of embankments for the first three to five years, and the development of unknown soft spots. Its application to existing railways with seasoned or consolidated roadbed, particularly on single track, would require an abandonment of traffic which would be somewhat expensive.

The conclusion that no part of the present track superstructure bears marks of engineering design seems hardly warranted in the face of mark of approval by one of our most eminent engineering societies of the cross-section of rail now most commonly used. The enormous cost of labor applied to surfacing and lining track seems somewhat hastily assumed, since one man to a mile is the amount of labor usually figured by railways which have very good track. In addition to lining and surfacing, weeds are cut, bolts tightened and other miscellaneous work is handled by this force, so that in a year's time the renewal of ties and surfacing and lining track will be found to form not over 50% of money paid for track labor. The roads with the finest track use more labor and the small, weak lines much less. For good track, such as is found on the ordinary road, an expense of $50 per month per mile of track for labor

only, will seldom be exceeded. The interest on the concrete substructure figured at $5 per cu. yd., which is less than the cost at which it could be handled unless the railway was abandoned until the work was completed, would be about $55 per month per mile.

In the first type suggested, it is stated that the surplus ballast should be picked up after the I-beams are applied. Who would care to pick up by hand (the only way which suggests itself) gravel ballast which costs to load at pit 3½ cts. per cu. yd., and about 5 to 10 cts. more (varying with haul) to deliver on the ground. It would be better to let it remain, although one function of the I-beam would be absorbed by it.

This I-beam type also provides for the rail to carry loads to the ties, the ties to the I-beams and the ballast to absorb the load. Should the ballast under the I-beam yield, and it is in a place where the greatest danger of yielding is to be anticipated, we would be back to the original design of the entire support being carried by the ties, with chances much in favor of a center-bound track.

The function of the wooden guard rail with its tendency to perish is not apparent. Why not bolt the ties directly to the I-beam and save the timber. The lateral fastenings between I-beams does not provide against overturning, which would surely occur with the forces unequally applied, as they will be. The replacing of the I-beam to its original position would involve considerable labor with unintelligent laborers to perform it. As a remedy for this difficulty it might be suggested to dap the tie on the underside to embrace the upper flange of the I-beam and to drop the rod to the lower flange. Cut out the superfluous guard rail, and allow the superfluous ballast to remain; it would cost at least $1 per yd. to remove it, and if left on the ground shows a loss of only 15 cts. With stone ballast, which is not stated as necessary, the saving might be worth while; but even this is doubtful, owing to difficulties to be encountered in handling work trains and the height to which it would be necessary to throw it to load on cars.

Accepting the type as feasible, I would suggest a reduction in the length of ties, the present length having been adopted to conform to the theory that with the load applied on the rail its proper distribution would be best effected by having the length outside the rail equal to that inside. With the I-beam as a distributor of pressure, its best position would seem to be a little outside the rail, the proper distance to be figured.

I would formulate conclusions as follows: (1) A cushion of workable ballast must be interposed between the bottom of the tie and any rigid bed of concrete or other material in order to provide for the irregularities of the thickness and of surface of the rigid bed; (2) Track superstructure must be so constructed that the cheapest class of labor can learn to maintain it when directed by men who are only one degree advanced above the common laborer; (3) It must be possible to restore track to about its original condition very quickly when destroyed by wreck or natural forces. The proposed form does not seem to meet these requirements.

I believe that much of our trouble in maintaining track to the desired degree of excellence arises from the flimsy fastenings. The ordinary spike will not preserve correct gage, which means difficulty in maintaining line. The tie is not held firmly to the base of rail which prevents self tamping, wasted labor in holding up tie when surfacing, and in driving spike to place. It also destroys the tie. All these add to difficulty in surfacing, and the poorest part of our track is the fastening between rail and tie. A properly designed tie-plate, with a lag screw and clip to unite the members, would assist more toward the economy of labor and material than any other modification from present practice. It might even be necessary to alter the form of rail to secure the best fastening, but the change would probably be a not undesirable one.

My criticisms are not intended to destroy Mr. Schaub's plan by one fell blow, but to bring out what I consider the important points of a most important question. The views advanced are based upon experience gained by riding on locomotives, passenger cars and motor cars, and going on foot in close inspection of track during a period of nine years, during which time the care of track has been directly under my charge. Exact design for track is difficult to evolve, since many assumptions must be made which may be more or less correct. The conclusion may be reached that when we have calculated pressures from wheel loads, the rest must be done empirically, except in the design of rail.

H. H. Knowlton,
Engineer Maintenance of Way,
C., C., C. & St. L. Ry.

Mount Carmel, Ill., June 15, 1907.

The Application of the Elastic Theory to Certain Forms of Arch.

Sir: Some question has been raised about the applicability of the elastic theory to arch analysis. It has been claimed that the elasticity of the abutments in the case of a reinforced-concrete arch is sufficient to cause a material change in the angle between the end tangents, and therefore because of this shifting of the end tangents the elastic theory becomes inapplicable. This is certainly an interesting and important contention, and the writer would like to see the matter discussed and, if possible, reports secured from those who have actually made observations to determine such shifting of the end tangents. Before attempting to discuss the first part of the contention, it would be well to free our minds from some of the notions carried over from masonry arch construction. Our usual conventional and arbitrary conception of the position of the spring line and the conventional separation of the arch ring and the abutments are relics of our older masonry arch practice, but with monolithic concrete

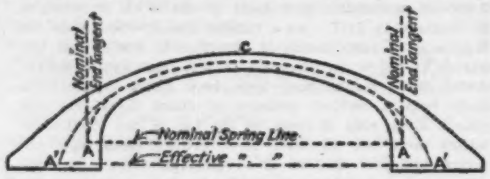


Fig. 1.

construction these terms lose much of their original significance.

There is no real dividing line between the arch ring and the abutment, unless the concrete is placed with that feature especially in view. Under the conventional usage of the word "abutment" it is undoubtedly proper to say that there is some shifting of the tangents as the arch takes its load. It has been customary to consider the arch ring as ending at an arbitrary point, and then apply the elastic theory to the portion above such arbitrary point. This customary treatment shows a relative large moment at the nominal spring line. This moment, of course, produces a lengthening of the fibers on the tension side of the arch ring, and a shortening on the compression side, and hence a change in curvature at that point, and a consequent shifting of the nominal end tangents.

This distortion of the fibers must be diffused throughout the mass of the abutment, and at some point reduced to a practical zero, or it would cause a slight turning of the abutment about the center of pressure at the base. Undoubtedly the weight of the mass of the abutment and the passive reaction of the earth's load tend to make the abutment approach the condition of a fixed end.

Now, granting that there is a shifting of the end tangents at the nominal spring line, we have only to drop lower down until we reach the point where such shifting ceases and start our true lineal arch from the effective spring line passing through this point, or, in other words, if the actual structure shows that the nominal end tangents are not fixed we have only to drop down to a point where practical experience shows no appreciable shifting of the end tangents. If it should develop that there was no point in the abutment at which the tangent remains fixed, we could consider the arch as hinged and free to turn at some point in the base of the abutment, or perhaps it would be more accurate to say that such a condition is between a true hinge and a true fixed end.

This leads us up to the second part of the contention. For the purpose of making myself better understood, I will call attention to the three fundamental equations of condition for elastic arches:

$$(1)\quad \triangle\phi = \int \frac{M\,ds}{E\,I}$$

$$(2)\quad \triangle x = -\int \triangle\phi\, dy$$

and

$$(3)\quad \triangle y = -\int \triangle\phi\, dx$$

(Howe)

Substituting the value for $\triangle\phi$ in equations (2) and (3) and integrating once, we have

$$(2')\quad \triangle x = -\int \frac{M\,y\,ds}{E\,I}$$

and

$$(3')\quad \triangle y = \int \frac{M\,x\,ds}{E\,I}$$

(Church)

Not to obscure the real point at issue, I have neglected the axial stress, and have regarded the temperature as remaining constant. Now if the angle between the end tangents changes, $\triangle\phi$ instead of reducing to zero, as is ordinarily assumed in analysis, would have some finite value. This value might be determined experimentally, or it might be worked out by a cut and try method, thus:

First—Assume that the three fundamental integrals reduced to zero, and then determine the moment arising at the successive increments of the arch rib, and with such approximate values used in equation (1) determine an approximate value for $\triangle\phi$. This value could then be utilized in a second solution by substituting in equations (2) and (3), and thus a new set of moments could be determined, and with these new moments a second and closer approximation for $\triangle\phi$ could be made. This might be carried to any degree of refinement desired. I realize that this would be something of a task, and merely cite the instance to emphasize the fact, which we might otherwise lose sight of: that these three fundamental equations are applicable to an elastic arch whether the $\triangle\phi$ and $\triangle x$ and $\triangle y$ reduce to zero, or become equal to some finite quantity. If it is a fact that the actual arch, as built, shows movement at the abutment, that does not in my mind invalidate the three fundamental equations. These three fundamental equations are susceptible of experimental verification as well as mathematical demonstration. Our method of applying these three fundamental equations may properly be called in question, but not the equations themselves.

I believe that the lack of correspondence between theory and practise in this case is due to the inaccuracy of adopting a nominal spring line and a nominal arch without regard to the modifying effect of the mass of the abutment upon such nominal spring line and arch axis. Referring again to my sketch, I maintain that the true neutral axis for the arch is affected by the mass in the abutment, and would occupy a position somewhat as indicated by the dotted line A' C A' in the sketch (Fig. 1). Likewise the true position of the spring line is affected by the mass in the abutment, and should be recognized as occupying a lower position, roughly indicated by line A' A'. The abutment is but a continuation of the arch ring, and the shape of such abutment influences the position of the lineal arch.

For example: In the case of an elliptical arch, it is not justifiable to consider the ellipse as coming on through the abutment and crossing the spring line at right angles, but rather the end portion of the ellipse loses its sharp curvature, and is drawn away from the center of the ellipse and approaches the back of the abutment as indicated in my sketch. In 1904, while working out a 90-ft. arch for the Board of Park Commissioners of this city, I realized this condition and for the end portion of the ellipse substituted a tangent making 45° with the horizontal. It seems to the writer that we would approximate the actual condition more closely by assuming our effective spring line some distance below the nominal spring line, and the arch axis as passing through the centers of gravity of the successive sections of the abutment, and recognizing that

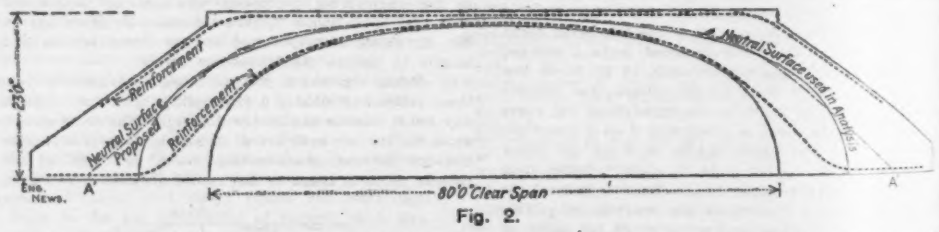


Fig. 2.

the arch ring and the abutment have a variable moment of inertia, such inertia becoming relatively large at our theoretical spring line. We would then assume conditions more in correspondence with the actual condition of the material arch.

I enclose an outline tracing (Fig. 2) taken off of a blue print prepared this spring by one of the larger reinforced-concrete companies. This is a case of an elliptical arch analyzed according to the ordinary assumption, and in which the neutral axis was considered to be unaffected by the mass in the abutment. A little consideration will show that the neutral axis could not actually occupy such a position as indicated without a very peculiar distortion in the abutment, which would be contrary to any experimental evidence that we now have. A closer approximation would have been effected by replacing the end portions of the ellipse with some such curve as indicated by the dash-and-dot line A' A'.

The writer would like to hear from others along this line, and especially from those who have had opportunity to measure the amount of shifting of the end tangents and observe any other distortion in the abutment.

Yours truly,
R. C. Barnett.

Kansas City Life Bldg., Kansas City, Mo., June 27, 1907.

[The difficulty as to the exact location of the

ends of an arch, and the shape of the arch axis near the ends, is not peculiar to concrete or reinforced concrete, but applies in exactly the same degree to stone arches. Whenever the shape of an arch does not show a pronounced change of resisting section from ring to abutment, or whenever the abutments are so high or of such form that they cannot be called "fixed," then any elastic analysis must include the whole structure down to the foundations. We say foundations, because in any event the foundation level will probably have unit pressures so low as to make the differential distortions, due to loading the arch, inappreciable. In some cases the designer may select some other point, above the foundation, as a plane of virtual fixity. A letter of Mr. D. B. Luten in our issue of May 2, 1907 (p. 490), calling attention to this matter, shows a bridge which is cited as an example of the inapplicability of the elastic theory if the ordinary procedure of calculation is followed. But much more striking illustrations of this condition are not at all rare in arch design.—Ed.]

Notes and Queries.

A. C. M. is considering a proposition to spray fuel oil into a furnace with compressed air instead of steam, and would appreciate any information on the subect.

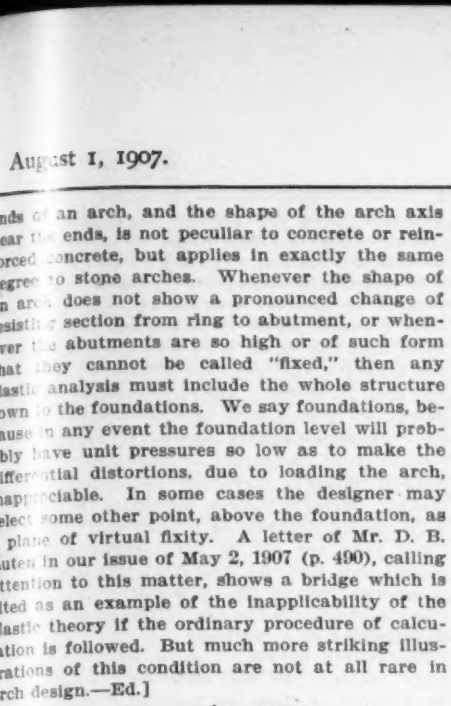
The pumping engine for the water-works system of Chicago, described in our issue of July 25, has a duty of 165,000,000 ft.-lbs. per 1,000 lbs. of dry steam, instead of 162,500,000 ft.-lbs., as stated. The error occurred in th estatement furnished us by the builders.

INCREASING THE CAPACITY OF OLD WATER-WORKS PUMPING ENGINES.

By A. P. BLACKSTEAD,* M. E.

It may prove advisable or advantageous at some time to increase, without the expense of having new and special castings made, the capacity of the pumping engine in some long-established water-works—where the engine is an "old timer." A means for doing this is here described.

The accompanying cut shows the type of water-valve generally used in pumping engines. By chipping or filing the rim and ribs of the seat, say 1/16-in., an increase in valve area of from 15 to 25% may be gained. The consequent decrease in strength is not material.



Plan and Vertical Section of Water Valve of Pumping Engine (Portions Chipped Off to Increase Pump Capacity.)

As is generally recognized, it is the contracted area through water-valves which causes the "knock" or "water hammer" that limits the piston speed; whereas the speed limits of the steam end, whether of the direct-acting or flywheel type, are much higher. Consequently, an increase in valve area will allow a proportionate increase in speed and capacity.

To illustrate the foregoing statement, let us consider a direct-acting pumping engine with a capacity of say 5,000,000 gals. in 24 hours. If this engine was built 10 years ago it will hardly have more than 50% valve area; and if so, the maximum allowable piston-speed will not be above 100 ft. per min. Further, if this engine is fitted with, say, 3½-in. valves of a sufficient number to give the above-mentioned 50% of valve area, the area that may be gained on each valve by chipping as described will equal 0.98 sq. ins., changing the area from the original 5.21 sq. ins. to 6.19 sq. ins.

This changes the total valve area from 50% to about 60%. Since the piston speed can be increased nearly in the same proportion, the capacity of the engine will be 6,000,000 gals. per day instead of the former 5,000,000 gals.

*With Camden Iron Works, Camden, N. J.

A NEW LUBRICANT—THE "ACHESON EFFECT" AND "DEFLOCCULATED GRAPHITE."*

By EDWARD G. ACHESON,† M. Am. Inst. E. E.

In the year 1901 I was engaged in a series of experiments having as their object the production of crucibles from artificial graphite. In this work I was led into a study of clays. What I learned may be briefly stated as follows: (1) The American manufacturers of graphite crucibles imported from Germany the clay used by them as a binder of the graphite entering into the crucibles. (2) The German clays are much more plastic and have a greater tensile strength than American clays of very similar chemical composition. (3) Residual clays—those found at or near the point at which the parent feldspathic rock was decomposed—are not in any sense as plastic or strong as the same clays are when found as sedimentary clays at a distance from their place of origin. (4) Chemical analysis failed to account for those decided differences.

I reasoned that the greater plasticity and tensile strength were developed during the period of transportation from the place of their formation to their final bed, and I thought it might be due to the presence of extracts from vegetation being in the waters which carried them.

I made several experiments on clay with vegetable extracts, tannin being one of them, and found that a moderately plastic, weak clay, when treated with a dilute solution of gallotannic acid or extract of straw, was increased in plasticity; was made stronger, in some cases as much as 300%; required but 60% as much water to produce a given degree of fluidity; was caused to remain suspended in water, and made so fine in particles that it would pass through a fine filter paper. Being acquainted with the record of how the Egyptians had the Children of Israel use straw in the making of bricks, and believing that it was used not for any benefits derivable from the weak fibers but for the extract, I called clay so treated "Egyptianized Clay."

Having in 1906 discovered a process of producing a fine, pure, unctuous graphite, I undertook to work out the details of its application as a lubricant. In the dry form, or mixed with grease or oil, it was easy to handle; but I wished it to enter the entire field of lubrication now occupied by oil. In my first efforts to suspend it in oil I met the same troubles encountered by my predecessors in this line of work; it would quickly settle out of the oil. My unctuous graphite was just plain, simple graphite, and obeyed the same laws as those which govern the natural product.

THE "ACHESON EFFECT" ON GRAPHITE.

So things stood until the latter part of 1906, when the thought occured to me that tannin might have the same effect on graphite that it did on clay. I tried it with satisfactory results, the "effect" being obtainable with the natural graphites as found in the Ticonderoga and Ceylon varieties, and with the artificial product as found in Acheson graphite. It was more easily and cheaply produced when the soft, unctuous variety of my graphite was used, this variety being composed of pseudomorphs of carbide crystals which had been decomposed in the electric furnace, the resultant graphite being very loose, porous and readily disintegrated and deflocculated. The effect was produced by treating the graphite in the disintegrated form to a water solution of tannin, the amount of tannin being from 3% to 6% by weight of the graphite treated. The results are much more pronounced when the mass of graphite, water and tannin has been pugged or masticated for a considerable time; I have advantageously carried on this process continuously, without interruption, for a period of one month. I have also found that while the effect may be produced in a very satisfactory way with distilled water, the greater number of waters as found in rivers, deep wells, etc., are improved by the addition of a trace of ammonia.

The accompanying photographs show the effect of tannin in suspending graphite. Fig. 1 shows two test tubes, one containing Niagara River water and disintegrated Acheson graphite, the other tube containing a similar amount of water and graphite, with the addition of a little gallotannic acid and a drop of ammonia. This photograph was taken immediately after the tubes were thoroughly shaken. Fig. 2 shows

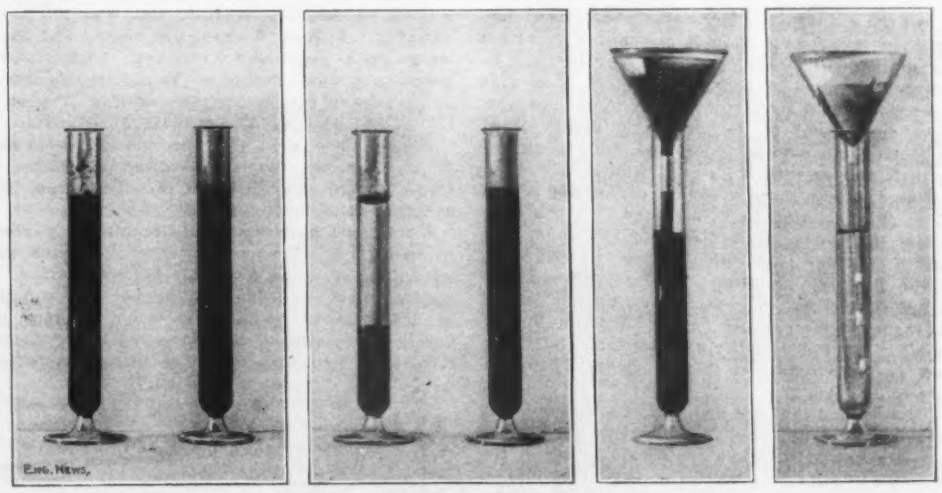


Fig. 1.—Tubes immediately after shaking.

Fig. 2.—Tubes four minutes later.

Fig. 3.—Deflocculated graphite passing through fine filter paper.

Fig. 4.—Retention by filter after flocculation with hydrochloric acid.

THE "ACHESON EFFECT."
EFFECT ON FILTERING PROPERTIES.

*This article is adapted by the author from a paper presented by him at the 24th annual convention of the American Institute of Electrical Engineers on June 27.

†President of the International Acheson-Graphite Co., Niagara Falls, N. Y.

the same tubes and contents, four minutes having elapsed after being shaken, the tubes having been undisturbed during that interval. These tubes furnish a very clear demonstration of the quick settling of graphite in plain water and the remarkable effect of the presence of tannin.

Not all of the graphite put into the tube with the tannin remained suspended. In fact, in this case illustrated very nearly all of it had settled, only a sufficient amount remaining in suspension in the water to give it its blackness. To cause a complete "deflocculation" and suspension of all the graphite necessitates prolonged mastication in the form of a paste with the water and tannin; and I find that after this mastication has been carried out the effect is very much improved by diluting the mass with considerable water, allowing it to remain for some weeks with occasional stirring.

After the prolonged mastication and additional time of exposure of the graphite to the water and tannin, an intensely black liquid is obtained consisting of water, the small amount of tannin, and the contained graphite; the last may be present in varying amounts. I have found that this liquid would pass through the finest of filter papers and that the contained graphite would remain in suspension for weeks and months—apparently for all time. A graphite content of 1% makes the liquid so thick that it runs through the filter paper slowly; reduced to 0.2%, it goes through quickly.

"DEFLOCCULATION."

Figs. 3 and 4 illustrate an experiment with water containing 0.2% of graphite. In this form I call the graphite "deflocculated"—a state of subdivision much finer than it is possible to attain by mechanical means; one that may perhaps be correctly spoken of as molecular. It is in that condition called "colloidal." This term, however, does not appeal to me; the term deflocculated is much more readily understood, and, to an extent, it carries with it its own definition.

Fig. 3 shows a glass funnel containing a fine filter paper resting in a test tube. In the tube below the funnel is a black liquid, which has passed through the filter paper. This black liquid is water containing 0.2% of deflocculated Acheson graphite. The fact of its having passed through the filter paper leaves no doubt in our minds of the impossibility of separating the water and graphite while in this condition by filtration.

I have found that the addition of a very minute amount of hydrochloric acid causes the contained graphite to flocculate—i. e., to group its particles into larger particles so that it no longer will pass through the paper. Fig. 4 shows, as in the former case, the funnel, filter paper and test tube; but now in the lower part of the tube, below the filter, we find a clear solution. This is the water in which the deflocculated graphite was formerly suspended, the graphite now being caught entirely in the filter paper above. It will be noticed that the filter paper in Fig. 3 is black on the outside, this having been produced by the deflocculated graphite passing through the paper; whereas the filter paper shown in Fig. 4 remains white on the outside, the graphite not having passed through its body.

This effect is obtainable with amorphous bodies generally; I have secured it with alumina, lampblack, clay, graphite and siloxicon.

USE OF GRAPHITE WATER LUBRICANT.

I have successfully used deflocculated graphite in water, instead of oil, in sight drop-feed oilers and with chain-feed oilers. I have a shaft in my laboratory measuring 2⁹/₁₆ ins. in diameter, revolving at 3,000 r. p. m. in a bearing 10 ins. long that had no oil on it for a month, deflocculated graphite and water being the only lubricants used, the feed being by chain; this bearing ran perfectly. On the same shaft is a similar bearing lubricated with oil, and this ran much the warmer of the two.

A few days after this test was started a

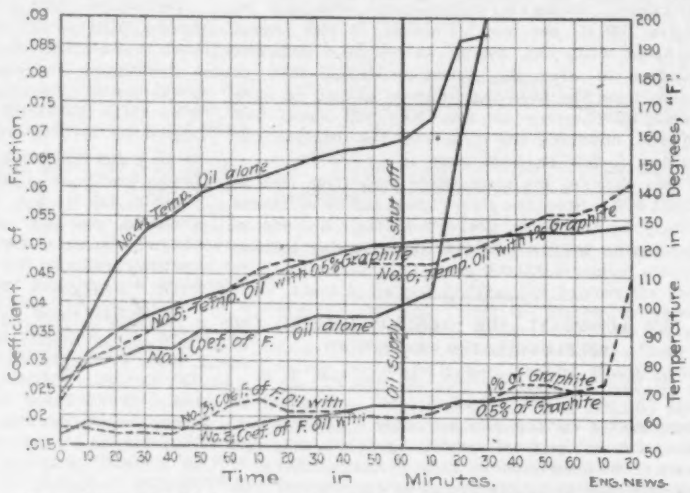

Coefficient of Friction.
Temperature in Degrees, F.
Time in Minutes.
ENG. NEWS.
No. 4, Temp. Oil alone
Shut off
No. 5, Temp. Oil with 0.5% Graphite
No. 6, Temp. Oil with 1% Graphite
No. 1, Coef. of F. Oil alone
Oil Supply
No. 3, Coef. of F. Oil with 1% of Graphite
No. 2, Coef. of F. Oil with 0.5% of Graphite

FIG. 5. DEFLOCCULATED ACHESON GRAPHITE COMPARED WITH OIL CURVES, SHOWING RESULTS OF TESTS BY PROF. C. H. BENJAMIN, OF THE CASE SCHOOL OF APPLIED SCIENCE, CLEVELAND.

Pressure on Bearing, 125 lbs. per sq. in.; Speed, 445 R. P. M.; Feed of Lubricant Same in Each Case.

pessimistic friend remarked that just plain, simple water would give the same results—that the presence of graphite was unnecessary. We are influenced by the opinions of others even when we know or think they are wrong. I emptied the oil out of the second bearing on the shaft and substituted plain water. The results during the first twelve hours seemed to support the contention of the friend. The next day, after the machine had stood motionless over night, things did not look so rosy for the water; it was a lame second on account of rust, and was hurriedly removed. I think I shall not recommend clear water as a permanent lubricant. Deflocculated graphite in water possesses the remarkable power of preventing rust or corrosion of iron or steel.

SUSPENSION OF GRAPHITE IN OIL.

The graphite, even after flocculation, is so fine in its particles that when dried en masse it forms a hard substance. It is self-bonding, like a sun-dried clod of clay.

While, as I have stated, deflocculated graphite in water is an excellent lubricant, it has the disadvantage of losing its water by evaporation. I realized that to utilize the possible advantages of deflocculated graphite, it would perhaps be necessary to replace the water with oil; therefore, I set before me the task of accomplishing that result. The production of a molecular form of graphite which would remain suspended in water for an indefinite period carried us on to what might figuratively be considered high ground; and when it is remembered that a removal of the water by evaporation previous to its replacement by oil would cause the contained graphite to assume the condition of a hard, flocculated, self-bonded mass like that to which I have referred, it will be seen that the problem was not simply one of evaporating the water and suspending the resultant dry graphite in oil.

A great deal of difficulty and many discouraging conditions were met with in the attempt to cross this apparently bottomless chasm, but I am pleased to say that I eventually succeeded and have been successful in suspending the deflocculated graphite in oil in a dehydrated condition; the graphite will remain suspended in the manner that it formerly did in the water. In this article we have a truly new lubricating medium.

COMPARATIVE SERVICE TESTS.

Prof. C. H. Benjamin, of the Case School of Applied Science, Cleveland, O., is engaged in making extensive tests to determine the value of deflocculated graphite as a lubricant, and, while these tests are not as yet completed, he has proved that 0.5% by weight of this graphite in oil greatly reduces the coefficient of friction and materially extends the life of the oil in which it is suspended as a lubricant.

The curves in Fig. 5 show some of the results obtained in his tests with spindle oil; by a study of them we find, by comparing the initial coefficient of friction with plain oil and that with oil containing 0.5% of graphite, that the coefficient of friction with the oil containing the graphite was but 65% of that with the plain oil; after 60 minutes it was but 55%, the friction of the oil having increased 54%, while with the contained graphite it increased but 30%. After shutting off the supply of the lubricant on the bearing, the coefficient of friction with the oil alone increased in 30 minutes 125%; whereas the coefficient with the oil containing 0.5% of graphite increased in 30 minutes but 14%.

Deflocculated graphite and oil when mixed do not form a simple mixture, but a new compound—a new substance. There is a slow union of the two. I cannot yet enter into the facts of this action, but for the present must confine myself to the simple statement.

NOMENCLATURE.

A new substance having been created, a new name had to be coined; I have added the initial letters of "Deflocculated Acheson Graphite"—D A G—to "oil" or "aqua," when the deflocculated graphite is carried in oil or water as the case may be, coining the words "Oildag" and "Aquadag" respectively.

LOWERING THE GRADE OF A TUNNEL AT KANSAS CITY, MO.

Changing the grade of a tunnel is work of an exceptional character, which calls for the exercise of special care and ingenuity. Important work of this kind in tunnels under the Chicago River has recently been carried out, and was described in our issues of Sept. 13, 1906, and March 7, 1907.

In the "Transactions of the Engineering Society of the South," for 1906 (Vol. xvii.) is a paper by Mr. W. M. Archibald* on the reconstruction of the 8th St. tunnel of the Metropolitan Street Ry., at Kansas City, Mo. The work was made necessary by changes in the rapid-transit system, including heavier cars and increased service, which could not safely be operated on the heavy grade of the old tunnel. The profile in Fig. 1 shows the general conditions, and Fig. 2 shows sections at two points. The following is an abstract of Mr. Archibald's paper:

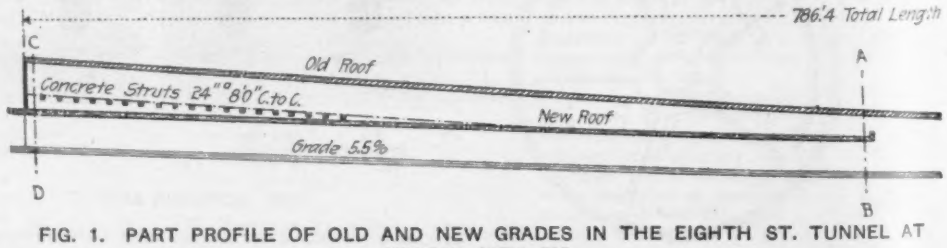


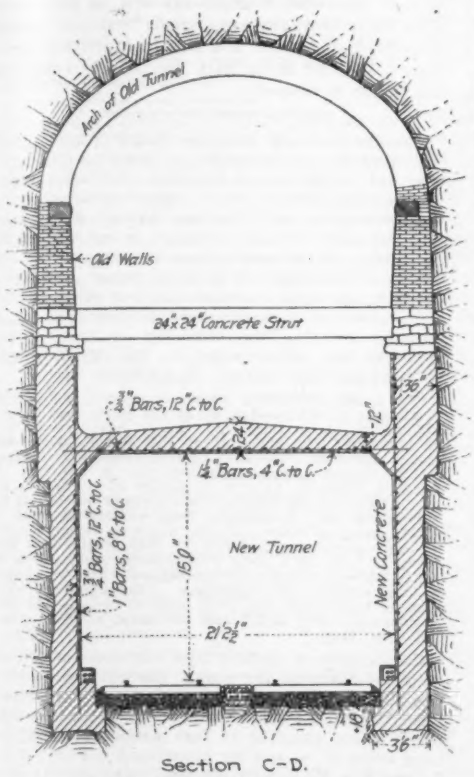
FIG. 1. PART PROFILE OF OLD AND NEW GRADES IN THE EIGHTH ST. TUNNEL AT KANSAS CITY, MO.

The tunnel is in a thickly settled part of the city, with a street lined with residences and a church and one house directly over the center line. The old tunnel

*With Ford, Bacon & Davis, Nashville, Tenn.

was a three-center brick arch, with a 26-in. arch ring of 21 ft. 2½ ins. span, and batter walls below the spring line. It was 786 ft. long, and on a grade of 8.648%. Not much could be learned of the geological structure of the bluff before starting the work, except that we would strike limestone and a very slippery shale. The shale makes a good foundation, and is in general a good material if it can be protected from air and frost. In view of this it was decided to protect it with a concrete lining reinforced with Johnson bars; and to cut the grade down to 5.51%, starting from the old elevation at the west end and extending the slope 543 ft. east to Broadway. This called for building 220 ft. of open-cut retaining walls, 323 ft. of cut-and-cover section of new tunnel (including a 33-ft. arch and station at Washington St.), and new roof and side walls wherever necessary under the old tunnel. To provide for the new approach, the street was widened for 20 ft. on each side for one block.

During the latter part of August, 1903, the contractors started a small gang excavating in the west end; and on Aug. 31 they had organized and commenced work at both ends. Their first move was to drive piling outside of the proposed excavation, to be used later to hold the sheeting as the excavation progressed.



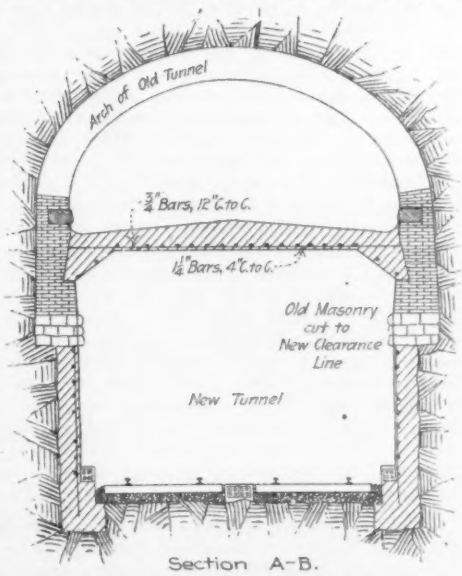


FIG. 2. CROSS-SECTIONS OF EIGHTH ST. TUNNEL, SHOWING RECONSTRUCTION.

The entire excavation was handled as an open cut and divided into two sections east and west from Washington St. The excavation east of this street was sublet and handled entirely with wagons. For the west, or tunnel, section all materials were handled in cars let down the grade on a 24-in. track by gravity and hauled back with a hoisting engine. This engine was installed at Washington St. and gradually lowered as the work progressed. It was used inside the tunnel until forced out by the track-laying gang. All excavated material from this section was wasted at the face of the bluff for the use of the Park Commission. The excavation under the old arch was handled by sinking a 12-ft. or 13-ft. ditch the entire length down to subgrade, and then gradually trimming the sides until only a 3-ft. or 4-ft. shoulder was left supporting the old footings. This shoulder and support of the walls was divided into alternate 10-ft. and 12-ft. sections, and excavation continued in the 12-ft. sections, going back 24 ins. under the old wall and 18 ins. below subgrade. These sections were filled and allowed to set for 10 or 14 days before the adjacent sections were excavated.

The material excavated was entirely shale and limestone in nearly level strata. For drilling, a Fisher direct-connected gasoline air compressor and two air drills were installed. Besides these, much of the drilling was done by hand with churn drills. After the first ditch was cut, the use of the air drills was practically abandoned on account of the greater ease of placing a hole by hand in a difficult location. All of the holes were shallow. Light shots were used, the heaviest charge being 2½ sticks of 40% dynamite in a 4-ft. hole. For drilling into the shale, an ordinary 1⅛-in. bridge auger, with the worm filed off, was used.

No trouble was experienced with the material, except at the east end of the old tunnel, where the excavation was the deepest. Here the shale had vertical seams; and as it had been exposed to the air and frost for years, it was dried up into small cubes, with almost no adhesion. The treacherous nature of the shale and the unevenness of the pile driving caused much more bracing to be used than would have been necessary otherwise. This bracing was later used to support the runways for the concrete barrows. For braces, the contractors used exclusively box struts of 8 × 8-in. planks spiked together, with a house jack in one end. We tried to break one of these struts in a test, but failed, breaking the jack instead. Only one cave-in occurred, and that was outside of the old tunnel on the side of what was formerly an old ravine..

Concrete was started on Nov. 28, 1903. A 1:3:5 mixture was used throughout, with Lehigh and Atlas cement, Missouri River sand, and ¾-in. limestone. One Smith mixer was used, and as high as 125 cu. yds. in ten hours was wheeled to the forms, 100 yds. being the usual day's work. For concrete forms, 2-in. plank was used exclusively.

The new portion of the new tunnel has a flat span of 21 ft. 2½ ins., reinforced with 1¼-in. corrugated bars 4 ins. c. to c. across the span, and ¾-in. bars 12 ins. c. to c. longitudinally. It has 24 ins. of concrete in the center and 13 ins. at the haunches, the side walls having an 18-in. 45° bracket to support the roof. This roof was 15 ft. in the clear from top of rail, and extended 300 ft. into the old tunnel. It was designed to act as a strut for the old side walls. Whenever no new side walls were built, a groove was cut into the brick, and dowel pins were also put in before the roof was concreted. At the mouth of the old tunnel concrete struts, 2 × 2 ft., 8 ft. c. to c., were put in between the foundations of the old walls. These are shown in the cuts.

All concrete was mixed on the surface and (by wheelbarrows and spouts) run into place by gravity. Whenever possible, the concrete under the old tunnel was wheeled in and dumped from the roof for the side walls. In other places it was dumped into a car and run down to the forms and shoveled in. In every case both sides were filled at once and kept at the same level.

In the east end, where the excavation was the deepest and the risk the greatest, a complete 10-ft. section of the new side walls and roof was completed and allowed to set before undermining the adjacent sections. The excavation for this section was made 12 ft. long, and all longitudinal rods were cut in 12-ft. lengths, allowing 1 ft. to project through the forms to bond on to the next section.

At Washington St. a station was located; and to provide width for the necessary platforms, the cross section was changed to a 33-ft. three-centered arch. This was reinforced with two rows of ⅞-in. bent bars, 7 and 9 ins., c. to c., and ¾-in. longitudinal rods 12 ins. c. to c., the arch ring being 15 ins. at the crown. The concreting of this arch was brought up to the spring line and allowed to set, and the balance of the concreting was carried on continuously until the entire arch was completed.

From the station east we expected to find a poor foundation, and provided for the same by putting in reinforced concrete beams below subgrade from one foundation to the other, forming a sort of a gridiron. This was done in earth for about 60 ft., and then an old fill was encountered, where it was almost impossible to get any foundation at all. So it was decided to make a complete concrete tube, and a solid 18-in. floor was laid, reinforced with old rails every 12 ins. This solid floor was necessary for about 200 ft. For the side walls of the open-cut approach, 18-in. batter walls, with slightly ornamental coping, was built. All reinforced rods used were corrugated bars, kept 3 ins. from the face of the forms.

The contract was taken by the General Construction Co., of Kansas City; R. W. Waddell, M. Am. Soc. C. E., General Manager. The price was a lump sum of $150,000. Excavation was pushed day and night. No attempt was made to get an exceptionally fine finish on the walls, as speed of construction consistent with strength and safety was the great object. No concrete work was done at night. The railway company's track laying gang and overhead men followed close on the concrete work, and track was being laid in one end as forms were going out of the other. On April 14, 1904, the new tunnel was opened for traffic; 7 months 14 days from the date of commencement. The work was done in connection with general street railway work for the Metropolitan Street Ry. Co., of Kansas City, under the supervision of Ford, Bacon & Davis, engineers, of New York; Mr. C. N. Black was engineer in charge of the Kansas City office.

HUMAN LIFE TOLL IN THE TRANSVAAL.

The most casual reader of one of the monthly reports of statistics of the Mines Department of the Transvaal—issued by the Government Mining Engineer's Office at Johannesburg, S. A.—will be apt to "sit up and take notice" when he reaches the page of data concerning accidents. Our American railways have an international—and deplorable—distinction in the magnitude of their annual tax upon the lives of traveling humanity; here will be found figures which, for so small a portion of the world's surface as that known as the Transvaal, compare most favorably (!) with our own annual railway mortality records.

The accident statement of the report for March, 1907, recently received, is a record one among reports of the twelve months ending March 31. One reason for this preëminence is that it includes the figures of the accident at the Driefontein Consolidated Mine in the Witwatersrand Area, by which six white men and 54 natives were killed, and one white man and two natives injured. In this connection it is pertinent to note that the number of whites killed and injured forms a very small percentage of the total—due, of course, to the fact that natives and Chinese make up the majority of the laboring force.

The gold mines appear in the accident statement as leaders in the mortality record; out of a total of 133 accidents of all kinds for the month the Witwatersrand gold mines scored 111, and 124 out of 132 total killed—94%—and 86 of 100 injured—86%—stand against them. A reference to the labor statement, earlier in the report, will show the reason for this apparent preeminence in gold mining as a "killer"; over 184,000 out of a total of 209,000—all classes of

TABLE OF ACCIDENT TOTALS IN THE TRANSVAAL.

Month.	Number of Accidents.	Killed			Injured			Total Killed and Injured.
		White.	Colored and Chinese.	Total.	White.	Colored and Chinese.	Total.	
1906—April.....	120	3	68	71	9	79	88	159
May.....	154	8	82	90	17	91	108	198
June.....	146	6	58	64	16	100	116	180
July.....	147	7	54	61	20	100	120	181
August....	141	4	50	54	19	92	111	165
September	134	7	61	68	19	80	99	167
October....	126	6	67	73	26	68	94	167
November.	134	7	58	65	20	85	105	170
December.	109	3	55	58	17	68	85	143
1907—January..	162	9	78	87	22	102	124	211
February..	114	7	45	52	11	70	81	133
March.....	133	12	120	132	15	85	100	232
Totals.....	1,620	79	796	875	211	1,020	1,231	2,106

mines and labor—are employed in gold mining, and of the 184,000 the Witwatersrand gold mines employ over 174,000, or about 95%.

To enable comparison of the March total with other months of the twelve which March completed, totals for those twelve months are tabulated herewith.

In the gold mines in South Africa, hoisting is done from such enormous depths that cable breakage is a not infrequent cause of disaster. At a recent meeting of the Transvaal Institute of Mining Engineers, a device was shown for detecting electrically any reduction, through wear, in the cross-sectional area of wire ropes.

It is understood that the Rope and Safety Catch Commission purpose trying this device in practice; we shall give in a later issue further details of its method of operation.

BENDING RAILS BY MACHINERY.

In laying rails it is usual to bend to the proper curve all rails for curves of more than 2° or 3°. This work is usually done by hand, but with heavy rails and numerous curves to be provided for, this is tedious and expensive work. In only a few cases, however, has machinery been employed to facilitate the process, but we have recently received particulars of some interesting work of this kind.

On the Franklin & Clearfield Ry. (a branch of the New York Central & Hudson River Ry. System in Pennsylvania) the maximum curvature

Curving Rails by Power; Franklin & Clearfield Ry. (New York Central Lines.)

is 6°, and in laying new 80-lb., 33-ft. rails the rails are bent for all curves of over 2°. The device used is the roller-bender made by Pettibone, Mulliken & Co., of Chicago, in which the rail is held on the outside by rollers at the ends of a yoke, while a third roller at the middle of the yoke bears against the inside of the rail and is adjusted to give the proper ordinate for the desired curve. This middle roller is ordinarily turned by a socket wench with a long crank handle, although occasionally a horse may be attached to a long sweep fitted in place of the crank handle. In curving rails by hand on this road, 12 men turned out 44 rails per day, at a cost of 50 cts. per rail.

In order to increase the output and reduce the cost, the plan was adopted of pulling the rails through the machine by a cable, and a 20-HP. double-drum hoisting engine was installed at the rail stock yard for this purpose. The cable has a snatch hook to engage with one of the bolt holes, and the rail is pulled from the stock pile to the machine (which is anchored in place), and then pulled through the rolls. The operation of curving consumes from five to seven seconds. When the rail has been pulled through, it is opposite the pile of curved rails. The hook is then taken off, and the rail is hoisted onto this pile by a cable which leads from the second drum of the engine to a gin pole at the back of the pile.

In this way from 175 to 225 rails are curved per day, at a cost of 35 cts. per rail. To facilitate the work, it has been found advantageous to move the bender and engine from pile to pile as each pile of rails is treated. The work is clearly illustrated in the accompanying cut. The men in the foreground are standing at the bending machine and a rail has been partly pulled through the rolls. When pulled clear through, the rails are hauled up the skids onto the pile as already described. For the photograph and information we are indebted to Mr. R. D. Tyler, Division Engineer, Franklin, Pa.

A different method, used on the Nashville, Chattanooga & St. Louis Ry., was described in our issue of May 31, 1906. Here the same style of bending machine was used, but the middle roll was driven by gearing from an 8-HP. gasoline engine. The output was given as averaging 100 rails per day and 20 cts. per rail, as against 50 rails per day and 35 cts. per rail when operating the machine by hand. This plant was installed at the yards, but it was suggested that it might be mounted on a car, with rail-loading devices to handle the rails to and from the car.

NOTES FROM ENGINEERING SCHOOLS.

WISCONSIN STATE MINING SCHOOL.—The Wisconsin State Legislature has appropriated $30,000 for the establishment of a mining school at Platteville.

UNITED STATES MILITARY ACADEMY.—The Board of Visitors has recommended a general revision of the curriculum, on the ground that it is not broad enough. The board states that it was necessary at first that the courses should be extremely technical, as there was no opportunity for post-graduate, military or engineering instruction. Such post-graduate courses have been successfully maintained for a few years, and this board maintains that the cadet should leave the academy with a general culture similar to that acquired in the best American colleges.

Y. M. C. A. EDUCATIONAL DEPARTMENT.—From October to June an evening course will be given in practical steam engineering, covering two years, at the Y. M. C. A. Building, 215 West 23d St., New York City. The first-year subjects include mathematics, physics, chemistry, heating and ventilating and boiler and engine construction. The second year is devoted to details of construction, erection and operation of various types of engines, boilers, pumps, condensers and auxiliary apparatus. Complete information may be obtained from Mr. B. B. Farnsworth, at the above address.

U. S. NAVAL ACADEMY.—The report of the Board of Visitors recommends that a new department for the study of electricity and its practical applications, with a naval officer in charge who shall be thoroughly familiar with electrical apparatus for marine uses. The report emphasizes the need of a requisite number of instructors, an adequate laboratory equipment, and sufficient allotment of the midshipmen's time.

COLORADO COLLEGE.—The Engineering School of this college has received the sum of $12,000, to be expended immediately on additional equipment of the engineering laboratories. The donor is Gen. William J. Palmer, formerly president of the Denver & Rio Grande R. R. and the Rio Grande Western Ry.

OXFORD UNIVERSITY, ENGLAND.—The proposition to institute a School of Engineering, as a part of Oxford University, is arousing great discussion in England. The opponents of the plan are outspoken and vigorous, while the defense is equally warm. The contention is shown in an extract from an editorial in the London 'Engineer, July 12:

> There can be little doubt that a chair of Engineering will be established at Oxford. It is hardly possible for the Chancellor, and for those who have worked with him, to retrace their steps, and it is improbable that any external pressure could affect the issue. The time for differences on matters of principle has passed; engineering, however much the opinion of many members of the University may be opposed to it, is to be taught at Oxford, and it behooves us all to see that, since it must be taught, it is well taught.

The science of mechanical engineering has been taught for many years in a small way at the Millard Laboratory. In view of this fact, the present proposition seems less radical than the current discussion would indicate.

The proposed chair is to be called one of Engineering Science in distinction to one of Engineering. Only principles and such applications will be taught as may be learned from lecture, text-book and light laboratory instruction. There will be no workshops or heavy plant. While practical shop and field experience is held to be of great value, yet the Oxford engineering student must gain this during the long vacation or after graduation.

Judging from the editorial just quoted, it is believed in England that the Oxford engineers will differ from the graduates of other scientific schools in a few important ways. For instance, it is expected that he will have all the peculiar qualities, coming from the University associations, which have long been attributed to Oxford men. Moreover, the positions in life of most Oxford students has been such that it is expected that Oxford engineers will be able to secure important and responsible positions through a considerable social and political influence, which poorer men or those with less noted connections could not command.

THE HELL-GATE BRIDGE PLANS WERE DISAPproved by the Art Commission of New York City a short time ago. According to the plans, the central feature of the bridge was to be a 1,000-ft. arch, carrying a four-track deck about halfway between the abutment and the crown level, as illustrated in our issue of May 30, 1907. Special architectural development was embodied in the plans; its principal feature, as concerns the arch, was a pair of immense piers or pylons at either end of the arch, rising far above the floor level, and apparently providing the impression of massive abutments to take the arch thrust. The Art Commission does not like these pylons. Its committee reported:

> Had these plans been purely structural and had the treatment of this bridge in all its parts been strictly utilitarian your committee would nevertheless have recommended the approval of the plans, though they would have regretted that this opportunity for artistic treatment had not been availed of. It has been attempted, however, to give decoration to the towers and to the bases of the towers. This attempt has not, in the opinion of your committee, been satisfactory from an artistic point of view. Your committee cannot approve of these decorative features, as they would have been ready to approve a strictly utilitarian construction, or, better still, a scheme of ornamentation which would seem to them artistic and appropriate. They therefore recommend disapproval of the plans without prejudice to their resubmission with a different treatment of their towers and their bases.

The Commission affirmed these sentiments of its committee and rejected the plans. The bridge proposed is intended to carry the New York Connecting R. R., a subsidiary corporation of the Pennsylvania R. R., from Long Island to the mainland at Port Morris, connecting the Long Island R. R. and the Long Island extension of the Pennsylvania R. R. with the New York, New Haven & Hartford Ry. The plans were developed by Mr. Gustav Lindenthal, as engineer, with the architectural cooperation of Mr. Henry Hornbostel.

THE PHILADELPHIA FILTRATION CONTRACT scandals became a matter of history with the award, on July 22, 1907, of over $2,000,000 to James P. McNichol and his associates in contracts and sub-contracts. This award was made by a referee agreed upon by the city authorities and the contractors.

In general, the referee holds that "there is no evidence of fraud, conspiracy or dereliction of duty on the part of the contractors or any ex-city official in connection with the award or execution of the contracts, with the exception that a certain contract awarded to the McNichol interests, while Mr. McNichol was a member of city councils, was illegal. The profits on this contract ($51,300), notwithstanding the fact that Mr. McNichol transferred his interests in it to his wife before the contract was carried out, are forfeited to the city. The concealment of this transfer, however, is held to be no fraud or conspiracy. The only other financial gain to the city, as a result of the litigation and final arbitration, is the award to the city of $5,700 for "pipe borrowed" from the city by the contractor. It should be understood that the decision of the referee, although terminating the controversy in question, is in no sense a court decision, but it was made by an ex-Judge of the State Supreme Court. Those interested in the details of the report of the referee can find them in the Philadelphia daily papers for July 23.

THE COLLAPSE OF A BUILDING at 120 Franklin St., Chicago, occurred on July 23, owing apparently to overloading of the floors. It was a six-story warehouse structure, and as the result of an inspection by the building commissioner last year the occupants were notified

that the floor loads should not exceed 125 lbs. per sq. ft. According to reports made after the failure the loads subsequently placed upon them were considerably higher.

THE BREAK IN THE COLORADO RIVER is reported as having been permanently closed on July 22. The river was brought under control, as many of our readers will remember, some months ago, after a comparatively brief period of effort, by the Southern Pacific R. R. Co. (see Eng. News, Feb. 21; another article on this work was published in our issue of May 16). Many will also remember that President Roosevelt called upon Mr. E. H. Harriman, President of the Southern Pacific, to close the break. It is stated that the railroad has expended nearly $1,500,000 on the work, and that future control of the river has been turned back to the California Development Co.

THE TAUERN TUNNEL in the Alps was broken through on July 21. The tunnel is 27,965 ft. long. Where the nature of the rock requires, which is only on less than 20% of the total length, it is lined with masonry. Machine drilling with Brandt rotary hydraulic drills, and hand drilling were used. Recent reports give the advance of the (bottom) headings for April as 370 ft. for the north heading and 427 ft. for the south heading; and for May, 1907, as 296 ft. in the north and 456 ft. in the south heading. The rock penetrated was generally a somewhat metamorphosed granite.

A BARGE CANAL CONTRACT WAS SUSPENDED by the Superintendent of Public Works of New York State on July 25. He has announced that the progress made on Contract No. 2 by the Ferguson Contracting Co. was not satisfactory, as less than a quarter of the contract work had been done in over two years. An extension of time to Oct. 15, 1908, had been granted the contractor. However, State Engineer Skene has reported his belief that the contractor would be unable to complete his contract by that time, and the contract, which was for something over $800,000, has therefore been suspended.

A 4,000 HP. ELECTRIC LOCOMOTIVE has just been completed by the Westinghouse Electric and Manufacturing Co., of Pittsburg, Pa. The locomotive was designed to suit the conditions to be obtained in the Pennsylvania Tunnels under New York City. Between the tunnels and outside levels it will be necessary to establish mountain grades on which the traffic must be handled at high speed. This has developed the necessity of using a locomotive more powerful than heretofore built of any type. In the preliminary tests alternating current was taken from overhead conductors at 11,000 volts, single phase. Further details of the tests and design are not at this time available. It is understood that this locomotive is built in competition for the Pennsylvania Tunnel contracts.

A SPECIAL TRAIN on the Bessemer & Lake Erie R. R. collided head-on with an engine running light, on July 22, in Greenville, Pa. The conductor was killed and six persons severely injured.

FIFTEEN PASSENGERS WERE INJURED in a wreck at Neelyville, Mo., on July 23, on the St. Louis, Iron Mountain & Southern Ry. The train was derailed, and some cars overturned. It is thought that a broken shoe on a tourist car worked loose and dropped on the rails.

A REAR-END COLLISION occurred on July 23 on the Philadelphia & Erie division of the Pennsylvania R. R., near Ferney, Pa. A fast passenger train ran into a freight, injuring about a dozen persons. The collision occurred in a dense fog.

A FREIGHT ENGINE STRUCK A PASSENGER TRAIN on the Southern Pacific Ry., near San Antonio, Tex., on July 22, wrecking the private car "Southwest," filled with Illinois and Missouri homeseekers. Every passenger in the car was injured, though no other cars in the train were damaged.

IN A FREIGHT WRECK on the Erie R. R., on July 22, near Aurora, Ohio, seven men were injured; it is expected that two will die. A tire came off a wheel on a switch engine coupled on at the head of the train, and both locomotives were overturned and the train piled up.

A TANK CAR FILLED WITH NAPHTHA capsized in a merchandise freight train on the Wabash R. R., near Eau Claire, Mich., on July 25. Three men were killed in the resulting explosion.

A LOCOMOTIVE BLEW UP while drawing a Wabash R. R. freight train near Simcoe, Ont., on July 26. Two of the train crew were killed and one fatally injured.

EXPLOSION OF A LOCOMOTIVE on July 18 on the Gulf line of the Mexican Central Ry., near Linares, Mex., killed the engineer, fireman and two brakemen.

AN EXCURSION TRAIN on the Bessemer & Lake Erie R. R. was wrecked on July 27 at Isle Station, near Butler, Pa. Three persons were instantly killed and 20 or more injured. Failure of a rail beneath the engine is the assigned cause.

A WRECK ON THE SOUTHERN RY. at Shipman, Va. (near Charlottesville), killed two persons and injured 13 on July 27. Train No. 36, northbound, ran into a split switch and derailed and wrecked the engine and two cars. Malicious tampering is believed responsible for the split switch; a freight train had passed it safely 45 min. before the wreck occurred.

AN ATTEMPT TO WRECK the Pocono Flyer on the Pennsylvania R. R., near Harmony, N. J., occurred on the night of July 28. Ties had been piled on the rails, and the engineer saw them barely in time to stop the train as it struck them; the pilot was smashed and a cylinder head blown out.

ANOTHER SERIOUS COLLISION occurred on the Cleveland & Southwestern Electric Ry. on July 24. Car No. 123, one of the two involved in the Memorial Day wreck, ran into a siding on which another car was standing—near Elyria, within a half mile of the scene of the previous wreck. Three persons were badly injured and about twenty less seriously.

CARELESSLY WRITTEN TRAIN ORDERS, it is maintained by the crew of the freight train involved, were responsible for the bad Pere Marquette wreck in Michigan on July 20. Minute examination of the order sheets by General Superintendent Trump, it is reported, showed from the careless alinement of the figures with the names of the stations that the crew's contention is probably justified. The Safety Appliance Board, now operating by authority of the Interstate Commerce Commission, will investigate the wreck through Prof. Mortimer E. Cooley, Dean of the Department of Engineering at the University of Michigan, Chairman of the Board (see Eng. News, July 18, p. 72.) Correspondence on file with the Interstate Commerce Commission shows that the Pere Marquette R. R. is not equipped with the block system.

THE STEAMER "FRONTENAC" BURNED on Lake Cayuga, N. Y., on July 27, and nine lives were lost. All were women and children, and perished by drowning. The boat was an old side-wheel, double-decked craft which has run on the lake between Ithaca and Cayuga for 25 years; she was built in 1866. The fire started in the engine-room and, under a strong wind, spread rapidly. There were 50 passengers on board.

A DISPATCH FROM COLON, PANAMA, reports the land about Lion Hill, ten miles from the town, to have sunk on July 30. Train service on the Panama R. R. was interrupted. It is not thought that the canal will be affected.

A REMARKABLE CANAL BREAK occurred in the Erie Canal at Syracuse, N. Y., on the afternoon of July 30. The canal crosses Onondaga Creek on a series of masonry arches. A leak developed in the canal bottom on this crossing, and soon after a section of the bed broke through, carrying down four canal-boats and incidentally wrecking parts of two factory buildings adjoining the canal. The canal level here is five miles long. Traffic is interrupted until the break can be repaired.

A REINFORCED CONCRETE TERMINAL WAREhouse has recently been completed at Newark, N. J., to facilitate the handling of the freight coming into that city on the New Jersey Central R. R. Trains are run directly onto the ground floor of the building where contents are unloaded and lifted by a complete elevator system, consisting of 14 elevators and eight gravity conveyors, to various floors where they are either unloaded directly for transportation or stored for future use. The structure is 370 × 140 ft. in plan and six stories high and contains over 370,000 sq. ft. of floor area. Fifty freight cars can be accommodated on the tracks inside the building and there is room for the storage of 1,200 carloads of freight.

A WATER HARDENING PLANT forming a part of the water-works of Bradford, England, was described by Mr. James Watson before the recent engineering conference held under the auspices of the Institution of Civil Engineers. The water drawn by Bradford from the Thornton Moor drainage area comes in part from peaty and boggy land. Some 17 years ago it was found that the water was acid at times, particularly after floods, and that it had a solvent action on lead. It was also found that treating the water with 3 grains of "chalk" per imperial gallon neutralized the action of the water. This has been practised with success for 16 years. The "chalk" is added in the form of milk of lime, after which the water is passed through sand filters at the rate of 380 to 400 Imp. gals. per sq. yd. per day (2,207,000 to 2,323,000 U. S. gals. per acre.)

A CONCRETE DIKE extending along the Ohio River throughout the flood district in Allegheny County, Pa., to do away with flood damage, is under consideration by Mayor Kirschler and Director of Public Works Swan, of Allegheny. The cost of such a dike, 30 ft. high and 20 ft. wide at the top, using for the concrete gravel to be dredged from the bottom of the river, is estimated at $5,000,000; most of this would be expected from the property owners along the river.

Taking gravel from the bed of the river will not only prove an economy in construction, but will also widen and deepen the channel.

PANAMA CANAL PROGRESS for June, 1907, is reported as follows: Excavation in Culebra Division, 624,600 cu. yds., all from canal prism proper (as compared with 669,400 cu. yds. for May, 1907, and 207,800 cu. yds. for June, 1906); average per shovel, about 16,000 cu. yds. The rainfall during the month, distributed over 24 days, was 13.3 ins., about twice as much as for June, 1906. Excavation at Gatun, 75,000 cu. yds. Dredging in canal prism, 81,400 cu. yds. Locomotives in service, 141; 62 mi. of new track were laid and 3½ mi. of old track were removed. The total working force, exclusive of employees of the Panama Railroad, was 23,327. The Sanitary Department, covering both the commission forces and the railroad forces, reports 91 deaths. Of these 72 were among the 29,000 colored employees, 4 among 4,300 American whites, and 15 among 6,500 whites other than Americans. This is a decrease from the 96 deaths reported for May. There is a similar decrease in the deaths from pneumonia (30 against 33) and typhoid fever (8 against 13). There were no typhoid deaths among the white employees. There were no deaths whatever among the 1,200 white women and children living in Commission quarters in the Zone.

THE NEW YORK ELECTRICAL SHOW at Madison Square Garden, New York City, will be open from Sept. 30 to Oct. 9. It is expected that all kinds of electrical apparatus, from the smallest incandescent lamp to heavy generating machinery, will be exhibited by all the prominent electrical manufacturing concerns of this country, as well as by a few foreign firms. Madison Square Garden will be blocked out by three avenues, to be called Edison, Westinghouse and Franklin, and by three cross streets. The interior and exterior of the building will be profusely decorated with incandescent lamps.

THE NEW CHANNEL FROM BALTIMORE HARBOR to deep water in Chesapeake Bay, under construction under the supervision of Col. Richard L. Hoxie, Corps of Engineers, U. S. A., M. Am. Soc. C. E., is the text of a part of his report to the War Department for the year ending June 30, 1907. The work is about two-fifths completed, and indications are that by the end of 1909 Baltimore will be provided with a channel 35 ft. deep, 600 ft. wide and 23 miles long. The project was adopted by Congress on Mar. 3, 1905, and work was begun on July 5 of the same year. Two clam-shell and two suction dredges are at present engaged in the work. The original depth of the channel prior to 1853, before any operations were begun by the Government, was 17 ft., with a mean range of tide of a little more than 1 ft.

THE 30-FT. SHIP CHANNEL under construction from Philadelphia to the sea, on which exceptional progress was made during the year ending June 30, 1907, is expected to reach completion some time next year. Major J. C. Sanford, Corps of Engineers, U. S. A., who has had the supervision of the work, on July 10 sent a report to the War Department at Washington for the fiscal year ending June 30, showing the immense amount of improvement work done. Up to June 30, 1907, the sum of $4,936,550 was spent in the work of dredging and of constructing bulkheads for the reception of dredged material and to act as training walls to direct the currents. Over 35,000 ft. of bulkhead has been built, and 30-ft. channel aggregating 76,000 ft. in length has been dredged. The greatest draft of water that could be carried at mean low-water on June 30, 1907, over the shoalest part of the river, below Philadelphia, was about 23 ft. The dredging of this part of the channel to 30 ft. has recently been begun. It is proposed to apply the available funds to completion of the project and maintenance of the already dredged channel. This will include widening of the channel beyond 600 ft. at the bend below Philadelphia, as well as dredging and rock removal in other sections.

STREET RAILWAY CAR-HOUSES are to be reported on at the coming meeting of the American Street and Interurban Railway Engineering Association in October, 1907. The report will be prepared by a committee on operating and storage car-house designs. Mr. Fred. N. Bushnell, of the Stone & Webster Engineering Corporation, 15 Exchange St., Boston, is one of the members of the committee. The report will "consist of a compilation of plans and synopsis of specifications of some of the

more recent types" of car-houses. Besides specifications, the committee requests descriptions of such houses, and also drawings or photographs showing front elevation, drawings showing plan of tracks, pitroom, etc., cross-section of walls, roof and pits and detail drawings of special features.

FIRE INSURANCE LOSSES BY STREET RAILWAY companies are to be investigated in detail by the Committee on Insurance of the American Street and Interurban Railway Association (Bernard V. Swenson, Secretary, 29 West 39th St., New York City). The committee has prepared a blank for use by the various members of the Association in reporting, for the years 1901 to 1907, inclusive, the amount of insurance carried, premiums paid and average rate of insurance per $100, contributions to insurance fund, losses incurred and amounts received. Further particulars bearing upon fires are included in the inquiry, such as the cause of fire, protective devices used, and reductions in rates secured during the last three years. In a report which will be found in the Proceedings of the Association for 1906, the committee named above submitted a "complete resumé of insurance matters so far as they affect street and interurban railways." The report showed material reductions in the rates of a number of companies during the past three years, as a result of the work of the committee.

COMPLETION OF THE SECOND SIMPLON TUNNEL was recommended to the Swiss Legislature by a committee delegated to examine the report of the State Railways. The Simplon, it will be remembered, was projected to have two single-track tubes, of which the second was for the present to be put through as a heading only, giving facilities for ventilation, drainage, etc., and permitting subsequent full excavation when traffic needs would call for it. The original contract provides that the completion of the second tunnel, if ordered before Feb. 23, 1908, may be made part of the first contract, and the committee recommends that this be done.

THE NEW TURBINE LINER "CREOLE," the first large American turbine steamship, was placed in commission on July 9 by the Southern Pacific Co. She left New York on July 14 for her maiden trip in the New York-New Orleans service.

The "Creole" was built by the Fore River Shipbuilding Co., and is one of three vessels of her size and type just added to the company's coastwise fleet; she is the only one of the three that is turbine driven.

She is 440 ft. long, 57 ft. beam and 10,000 tons displacement, and has a speed of 18.5 knots per hour, with a cargo of 4,500 tons. She has 152 state-rooms and can accommodate 250 steerage passengers.

THE COAL CONSUMPTION OF TURBINE STEAMERS is a matter of special interest, and at a recent meeting of the Institution of Civil Engineers, of England, particulars were given of the turbine steamer "Virginian" of the Allan Line, running between Liverpool and Montreal. In a series of voyages it has averaged 17.2 to 17.65 knots at an estimated power of 12,700 Ind. HP. The average coal consumption was 1.30 lbs. per Ind. HP. for the propelling machinery alone, 1.42 lbs. including the auxiliary machinery, and 1,507 lbs., including also the electric light machinery.

THE SOUTH AMERICAN TRANS-CONTINENTAL Railway, which is to connect the Atlantic and Pacific Oceans via Argentine and Chile, is making excellent progress. It has been recently reported that that part of the road which is located in Chile is well advanced. As much work has been accomplished in the last six months on the tunnel through the backbone of the Andes as had been done in the previous 18 months. At the present rate the tunnel, which is at an altitude of 11,500 ft. and is about 2½ miles in length, should be completed by May 1, 1909. This will be the first place at which the Andes have ever been crossed by a railway.

A NAVAL REPAIR PLANT, whereby minor damages to the vessels of our navy on long cruises may be repaired without recourse to a navy yard, is a renewed proposition in naval circles. It has been proposed to fit out the "Culgoa," a supply ship, at the New York Navy Yard for this purpose.

VANADIUM STEEL FOR BIG GUNS is being experimented with by the Navy Department. Its toughness is thought to be a valuable asset in such work, and also in armor manufacture when used in conjunction with backing of softer, though tough, steel.

THE PROHIBITION AGAINST CARRYING petroleum through the Suez Canal, which has been in force several years, has been removed according to Consul-General R. J. Wynne, of London. This concession means much to European consumers, as about 250,000 tons are annually brought from Borneo and Sumatra.

PERSONALS.

Mr. C. M. Colburne has been appointed Chief Engineer of the Manitoulin & North Shore Ry. at Sault Ste. Marie, Ont.

Mr. E. J. Govern, Assistant Engineer of Bridges and Buildings for the Buffalo, Rochester & Pittsburg Ry., has resigned.

Mr. C. L. Peterson has been made Chief Engineer of the electric power stations of the New York, New Haven & Hartford R. R.

Mr. W. J. Eck was recently appointed Electrical Engineer for the Southern Ry. at Washington, to succeed Mr. G. W. Johnston.

Mr. M. H. McLeod, former Chief Engineer of the Canadian Northern Ry., is now General Manager with headquarters at Winnipeg.

Mr. H. T. Hulst has been appointed Chief Engineer of the Marquette Range mines of the U. S. Steel Corporation, to succeed Mr. Andre Formis.

Mr. V. E. Ohl has resigned as Chief Engineer for the Tennessee Coal, Iron & R. R. Co., having been appointed City Engineer of Ensley, Ala.

Messrs. Henry S. Washington, and J. Volney Lewis, M. Am. Inst. M. E., have opened offices at 95 Liberty St., New York City, as consulting geologists and mineralogists.

Mr. A. S. Blanchard has resigned as Manager of the steel-casting department of the Wellman-Seaver-Morgan Co., of Cleveland, to become Assistant to the Vice-President of the Atha Steel Casting Co., of Newark, N. J.

Prof. Arthur Maurice Greene, Jr., M. Am. Soc. M. E., has left the Chair of Mechanical Engineering at the University of Missouri to take charge of the corresponding department at the Rensselaer Polytechnic Institute, Troy, N. Y.

Mr. F. E. Butcher, formerly Manager of the foreign sales department of the Kilbourne & Jacobs Mfg. Co., of Columbus, Ohio, has been elected Vice-President and General Manager of the American Concentrator Co., of Joplin, Mo.

Mr. Hoge Gilliam, formerly Erecting Engineer at Philadelphia for the Westinghouse Electric & Mfg. Co., has been appointed Electrical Superintendent for the New York, New Haven & Hartford R. R., with offices at Stamford, Conn.

Dr. David T. Day, of the U. S. Geological Survey, heretofore in charge of the Division of Mining and Mineral Resources, has been relieved of duty at the head of that division and will devote his entire time to a study of the petroleum resources of the country.

Mr. W. B. Causey, heretofore Engineer of Maintenance of Way for the Chicago & Alton Ry., has been appointed Superintendent of the eastern division of the same road, at Bloomington, Ill., to succeed W. L. Derr. Mr. Derr resigned to become General Superintendent of the New York City Ry. Co.

Mr. J. S. Viehe, Assoc. M. Inst. E. E., has been appointed Electrical Engineer to the Federal Construction Co., which is building the plant of the Rockingham Power Co., Rockingham, N. C. Mr. Viehe has been formerly with the Southern Power Co., and also Chief Engineer of the Greenville-Carolina Power Co.

Mr. G. W. Talbot has resigned as General Manager and Treasurer of the Corvallis & Eastern R. R., at Portland, Ore. The office of General Manager has been abolished. Mr. Geo. F. Nevins, former Auditor and General Freight and Passenger Agent, becomes General Superintendent, with headquarters at Albany, Ore.

Mr. J. F. Collins, formerly Superintendent of Railways for the Toledo Rys. & Light Co., has been appointed Manager of Railways with entire charge of transportation. Mr. C. R. McKay, who recently came from Cincinnati to Toledo to succeed E. J. Bechtel as Superintendent of Light and Power, is made Manager of Light and Power.

Mr. Geo. M. Wisner, M. Am. Soc. C. E., has been appointed Chief Engineer of the Chicago Sanitary District (including the drainage canal and water power plants). He succeeds Mr. Isham Randolph, M. Am. Soc. C. E., who, as stated in this column on June 27, has resigned after 14 years' service, but who will act as Consulting Engineer for the Sanitary District. Mr. Wisner has recently served as Assistant Chief Engineer of the District.

The following appointments have been made by State Highway Commissioner Hunter, of Pennsylvania, under the recent reorganization act passed by the Legislature: Deputy Commissioner, R. D. Beman, of Meadville; Assistant Commissioner, G. W. Ensign, of Warren. Engineers, C. F. Hamilton, of Franklin; F. P. Hallam, of McKeesport; C. W. Bosler, of Hollidaysburg; E. D. Garrett, of Downington; G. H. Biles, of Philadelphia; J. R. Wilson, of Washington; J. T. Gephart, of Lancaster; C. W. Hardt, of Camp Hill; A. W. Long, of Scranton; S. W. Jackson, of Meadville, and W. A. Wynn, of Pittsburg. Chief Draftsman, C. E. Douglass, of New Castle.

Obituary.

T. F. Osborn, an engineer specializing in reinforced concrete work with Contractor Carl Leonardt, of Los Angeles, died in that city on July 20.

John N. Gill, a prominent contractor and builder of Philadelphia, died of cancer at his home at 3010 North Broad St., on July 25. He was born in Philadelphia in 1856.

Joseph W. Zipperlein, Assoc. M. Am. Soc. C. E., Vice-President of the Wm. G. Hartranft Cement Co., of Philadelphia, died on July 22 after a short illness at his home in Ashbourne, Pa.

Wm. H. Story, for 35 years a city surveyor of Brooklyn, N. Y., died on July 25 at his home at No. 2111 Albemarle Road, Flatbush. He was born in Brooklyn in 1834, and was educated at the Erasmus Hall Academy. He was an expert on the Brooklyn water supply system, and had charge of the laying out of Woodlawn Cemetery and other large tracts.

Wm. Hamilton Russell, architect, of the firm of Clinton & Russell, 32 Nassau St., New York City, died recently while traveling in Europe. In 1878 he was graduated from Columbia University, and shortly thereafter entered the office of his great-uncle, James Renwick, the designer of St. Patrick's Cathedral; he was soon admitted to partnership in the firm, then known as Renwick, Aspinwall & Russell. Later he became associated with Chas. W. Clinton.

Albert Francis Hall, M. Am. Soc. M. E., Constructing Engineer with the Geo. F. Blake Mfg. Co., of Boston, died at Somerville, Mass., on July 22. He was born there in 1845. He entered the Massachusetts Institute of Technology at its opening, graduating with its first class—numbering ten—in 1868; he was the only mechanical engineer in his class. He studied further in the polytechnic schools of Hanover, Germany, and upon his return to America after a long sojourn there he allied himself with the Geo. F. Blake Mfg. Co., with whom he has been associated ever since. In the early days of his career he taught mechanical drawing at the Massachusetts Institute of Technology. He leaves four children—a daughter and three sons.

ENGINEERING SOCIETIES.

COMING MEETINGS.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Aug. 7-9. Annual meeting at Norfolk, Va., Secy., Frank P. Foster, Corning, N. Y.

CANADIAN INSTITUTE OF ARCHITECTS.
Aug. 19-23. First annual meeting at Montreal. Secy., Alcide Chausse, Montreal.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 27-30. Annual convention at Chicago, Ill. Secy., W. O. Thompson, Oswego, N. Y.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 10-13. Thirty-eighth annual convention at St. Paul, Minn. Secy., A. P. Dane, Reading, Mass.

NATIONAL IRRIGATION CONGRESS.
Sept. 23-28. Fifteenth annual convention at Sacramento, Cal.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Oct. 8. Annual meeting at Washington, D. C. Secy., Edw. A. Moseley, Interstate Commission, Washington, D. C.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 14-18. Annual convention of this and affiliated associations at Atlantic City, N. J. Secy., Bernard V. Swenson, 29 West 39th St., New York City.

AMERICAN STREET AND INTERURBAN RAILWAY ENGINEERING ASSOCIATION.
Oct. 14-16. Annual convention at Atlantic City, N. J. (See preceding item.) Secy., S. W. Mower, Southwestern Traction Co., London, Ont.

TRAVELING ENGINEERS' ASSOCIATION.—Convention headquarters (Aug. 27 to 30) will be at the Auditorium Hotel. Mr. F. F. Edwards, Mechanical Engineer, with the Ohio Injector Co., 1437 Monadnock Block, Chicago, is Chairman of the committee in charge of entertainment of delegates.

CANADIAN INSTITUTE OF ARCHITECTS.—This association is young, having been organized only last April. It is an affiliation of several provincial associations, including the Architects' Association of Ontario, and the Quebec Architects' Association. An attendance of about 200 delegates is expected at the convention.

MEXICAN INSTITUTE OF MINING ENGINEERS.—A society under this name is to be organized along the lines of the American Institute of Mining Engineers. The movement is an outcome of the meeting last year, at Mexico City, of the International Geological Congress. A committee has been appointed to draw up a constitution and by-laws.

APPALACHIAN ENGINEERING ASSOCIATION.—The summer meeting will be held at Newport News, Va., on Saturday, September 7. The association headquarters will be at the Hotel Warwick. The Secretary, Mr. N. H. Mannakee, of Williamson, W. Va., extends an invitation to all engineers who may be visiting the Jamestown Exposition, at that time, to attend the association sessions.

LEADING ARTICLES—
Destruction of Debris Barrier, Murphy, Associate Am. Soc. C. E.
The Locust Point Bridge.
Priming Coats for Steel Work, Am. Soc. T. M.
New Water Purification Plant, Assoc. M. Am. Soc. C. E.
Cost of Soap Drawing.
Notes on English Engineering.
Repairing a Limestone Arch (illustrated).
Some New Methods in Tunneling, Buck, M. Am. Soc. C. E.
A New Type of Locomotive, E. M. Hewlett.
Operations and Practice.
A Destructive Blast.
Notes on Tar Macadam.
A Warped Surface.
Cost of Small Concrete Work, Am. Soc. C. E.

DESTRUCTION OF DEBRIS BARRIER ON YUBA RIVER

By E. C. MURPHY,* Associate Am. Soc. C. E.

During a flood in 1906 on the Yuba River, Debris Barrier No. 1, constructed by the California Debris Commission for the purpose of holding back mining debris that was being swept down the river by floods, was destroyed. This structure was developed after careful study, and after the failure of a brush and rock dam built by the Commission on this site about a mile above the site of the barrier whose failure is worthy of careful study.

This structure is described in detail in reports of the Debris Commission, in the Transactions of the American Society of Civil Engineers, Vol. 57, p. [illegible], and briefly in Engineering News, Vol. 55, p. [illegible] (June 15, 1905).

From 1849 to 1884 enormous quantities of debris—sand, gravel, cobbles, the tailings of hydraulic mining—were deposited in the natural courses of the streams that drain the western slope of the Sierra Nevada Mts. in California. The volume of this material in the Yuba River has been variously estimated at from 71,000,000 to 700,000,000 cu. yds. At the mouth of the river, near Marysville, the deposit has a depth of 60 ft.; at Duguerre Point, 11 miles above the mouth, it has a depth of 26 ft.; and at Hammonton, 18 miles from the mouth, it has a depth of 84 ft.

This barrier is situated fourteen miles above the mouth of the Yuba River, where the stream leaves the foothills. The location is shown by Fig. [illegible]. It is anchored by piles [illegible] and consists of [illegible] (except the first [illegible]

*Engineer, U. S. [illegible]